

SECOND BIENNIAL REPORT TO CABINET ON

**THE STATE OF CLIMATE CHANGE
SCIENCE AND TECHNOLOGY IN
SOUTH AFRICA**



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The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science and scholarship for the benefit of society, with a mandate encompassing all scholarly disciplines that use an open-minded and evidence-based approach to build knowledge. ASSAf thus, adopted in its name the term 'science' in the singular as reflecting a common way of enquiring rather than an aggregation of different disciplines. Its Members are elected based on a combination of two principal criteria, academic excellence and significant contributions to society.

The Parliament of South Africa passed the Academy of Science of South Africa Act (No 67 of 2001), which came into force on 15 May 2002. This made ASSAf the only academy of science in South Africa officially recognised by government and representing the country in the international community of science academies and elsewhere.



TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS.....3

EXECUTIVE SUMMARY7

1 INTRODUCTION11

2 THE FINDINGS AND GAPS OF THE FIRST REPORT13

3 RECENT CLIMATE-RELATED RESEARCH FINDINGS OF POLICY RELEVANCE15

4 CLIMATE CHANGE SCIENCE AND TECHNOLOGY LANDSCAPE IN SOUTH AFRICA.....17

4.1 Research publications.....18

4.2 Who else publishes on Southern African climate change?21

4.3 The production of postgraduate researchers23

5 INVESTMENTS IN CLIMATE CHANGE S&T27

5.1 Preamble.....27

5.2 Investment levels and sources for climate change S&T.....28

5.3 Use of international climate finance opportunities available for SA.....31

5.4 Conclusions.....32

6 CLIMATE SCIENCE AND TECHNOLOGY IN THE PRIVATE SECTOR33

6.1 General introduction33

6.2 Focus areas for the private sector.....33

6.2.1 Financing mitigation and adaptation33

6.2.2 Financial disclosure and voluntary reporting36

6.2.3 Mitigation and adaptation activities36

6.2.4 Technology and product development38

6.2.5 Research and projects.....38

6.3 Energy sector research related to climate change39

6.3.1 Renewable energy39

6.3.2 Nuclear energy40

6.3.3 Coal41

6.3.4 Gas.....42

6.3.5 Energy storage42

6.3.6 Fuel cells and the hydrogen economy43

6.3.7 Small-scale embedded generation44

6.3.8 Waste44

7 UPDATE ON THE LEGISLATIVE AND POLICY ENVIRONMENT45

8 CONCLUSION47

8.1 Summary of major findings47

8.2 Recommendations.....48

REFERENCES.....50

APPENDICES54



APPENDICES

Appendix 1:	Panel members and biographies.....	55
Appendix 2:	Procedure for survey of journal and book publications.....	57
Appendix 3:	List of people and institutions consulted.....	63
Appendix 4:	Assessment of South Africa's leveraging of international funding instruments for climate change-related research and technology development	65
Appendix 5:	Investigation into activities and investments by the private sector of South Africa.....	104
Appendix 6:	Details of the data sources supporting funding analyses.....	117
Appendix 7:	Update of the review of legislation and policy instruments for climate change research and technology in South Africa.....	125

LIST OF FIGURES

Figure 1	The key institutions involved in funding, researching and responding to climate change in South Africa.	17
Figure 2	The rate of publication on topics related to climate change by authors affiliated with South African institutions over the period 2006 to 2017.	20
Figure 3	The number of publications generated in the years 2016 and 2017 on the same topics covered by the search for South African publications related to climate change.	23
Figure 4	Allocation of venture capital funds in South Africa to sectors, by value of deals (SAVCA, 2018).	36
Figure 5	Tariffs for wind, solar PV and all RE technologies across four bid windows in REI4P. (Source: Kruger & Eberhard, 2018).	40

LIST OF TABLES

Table 1	Published, peer-reviewed research outputs in the period 2016-2017 where at least one of the authors was associated with a South African institution.	19
Table 2	The number of Masters degrees (or Masters equivalents, following the South African Qualifications Authority classifications) and doctoral degrees awarded by South African HEIs in the period 2016-2017 on topics related to climate change.	23
Table 3	South African-affiliated researchers appointed to participate within governance, science or advisory panels or committees of major international climate-related research organisations.	25
Table 4	Sources and levels of investment (R million) in climate change S&T in South Africa, 2015-2017.	29
Table 5	International funding approved for sub-Saharan Africa (US\$ million) and the share used by South Africa during the period 2003-2017.....	31



ABBREVIATIONS AND ACRONYMS

AAS	African Academy of Sciences
AF	Adaptation Fund
AIIF	African Infrastructure Investment Fund
AIIM	Africa Infrastructure Investment Managers
AIMS	African Institute for Mathematical Sciences
ARC	Agricultural Research Council
ASSAf	Academy of Science of South Africa
BRICS	Brazil, Russia, India, China and South Africa
CACGP	Commission on Atmospheric Chemistry and Global Pollution
CCC	Confronting Climate Change
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CeSTII	Centre for Science, Technology and Innovation Indicators
CGIAR	Consultative Group on International Agricultural Research
CGS	Council for Geosciences
CICSA	Climate Innovation Centre South Africa
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CNG	Compressed natural gas
CO ₂	Carbon dioxide
COP	Conference of the Parties
CPUT	Cape Peninsula University of Technology
CSP	Concentrated solar power
CTF	Clean Technology Fund
CTL	Coal-to-liquid
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DST	Department of Science and Technology
DUT	Durban University of Technology
ECOSOC	Economic and Social Council
EFTEON	Enhanced Freshwater and Terrestrial Observation Network
ESASTAP	European South African Science and Technology Advancement Programme
ESIL	Energy Storage Innovation Lab
FSRU	Floating storage regasification units
GCF	Green Climate Fund
GEF	Global Environmental Facility
GEF	Global Environment Fund
GERD	Gross domestic expenditure and development
GHG	Greenhouse gas
GenderInSITE	Gender in science, innovation, technology and engineering
GMST	Global Mean Surface Temperature
HEIs	Higher education institutions
HSRC	Human Sciences Research Council
ICCFIs	International climate change funding instruments

ICFR	Institute for Commercial Forestry Research
ICT	Information and communications technology
IDC	Industrial Development Corporation
IDEAS	Infrastructural, Developmental and Environmental Assets
IEP	Integrated Energy Plan
IGCC	Integrated gasification combined cycle
iNeSI	iKamva National E-Skills Institute
IOC	International Ozone Commission
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent power producers
IRP	Integrated Resource Plan
ISPEC	Independent Science and Partnership Council
JSE	Johannesburg Stock Exchange
LDC	Least-developed countries
LNG	Liquefied natural gas
LTMS	Long-Term Mitigation Scenarios
MAPS	Mitigation Action Plans and Scenarios
MDG	Millennium Development Goal
MRC	Medical Research Council
MTSF	Medium-Term Strategic Framework
NBI	National Business Initiative
NDP	National Development Plan
NERSA	National Energy Regulator
NGOs	Non-governmental organisations
NMU	Nelson Mandela University
NPC	National Planning Commission
NRF	National Research Foundation
NSTF	National Science and Technology Forum
OECD	Economic Co-operation and Development
OWSD	Organisation for Women Scientists in the Developing World
PACE	Property Assessed Clean Energy
PE	Private equity
PGMs	Platinum group metals
PMR	Partnership for Market Readiness
P4RR	Partnership for Risk and Resilience
PSEE	Private Sector Energy Efficiency Programme
R&D	Research and development
R&TD	Research and technology development
RDI	Research, development and innovation
RE	Renewable energy
REDD	Reducing Emissions from Deforestation and Forest Degradation
REI4P	RE Independent Power Producer Procurement Programme
RIs	Research Infrastructures
RU	Rhodes University
SA	South Africa
SADC	Southern African Development Community
SAEON	South African Environmental Observation Network

SAIIA	South African Institute of International Affairs
SAIAB	South African Institute for Aquatic Biodiversity
SALGA	South African Local Government Association
SAMREF	South African Marine Research and Exploration Forum
SANBI	South African National Biodiversity Institute
SANCOOP	South Africa-Norway Research Co-operation on Climate Change, the Environment and Clean Energy
SANEDI	South African National Energy Development Institute
SANSA	South African National Space Agency
SARChI	South African Research Chair Initiative
SARIR	South African Research Infrastructures Roadmap
SASRI	South African Sugarcane Research Institute
SAWS	South African Weather Services
SCCF	Special Climate Change Fund
SCF	Strategic Climate Fund
SPARC	Stratospheric Processes and their Role in Climate
SSA	Sub-Saharan Africa
SSEG	Small-Scale Embedded Generation
S&T	Science and technology
SoE	State-owned enterprises
SMCR	Shallow Marine and Coastal Research Infrastructure
SMRI	Sugar Milling Research Institute
SU	Stellenbosch University
the dti	Department of Trade and Industry
TIA	Technology Innovation Agency
TUT	Tshwane University of Technology
TWAS	The World Academy of Sciences
UCT	University of Cape Town
UFH	University of Fort Hare
UJ	University of Johannesburg
UK	United Kingdom
UKZN	University of KwaZulu-Natal
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
UP	University of Pretoria
UCT	University of Cape Town
USA	United States of America
Univen	University of Venda
UWC	University of the Western Cape
UniZulu	University of Zululand
VC	Venture capital
VUT	Vaal University of Technology
Wits	University of the Witwatersrand
WoS	Web of Science
WSU	Walter Sisulu University
WWF	World Wide Fund



EXECUTIVE SUMMARY

This is the second biennial report on the *State of Climate Science and Technology¹ in South Africa*, commissioned by the Departments of Science and Technology (DST) and Environmental Affairs (DEA) and compiled by the Academy of Science of South Africa (ASSAf). The first biennial report, completed at the end of 2016 and covering the period 2005 – 2015, found that the academic research function was healthy and productive. The state of the industrial development aspects was less clear, and there was an obvious disconnect between the two.

This report put special effort into investigating research and development (R&D) activities relating to climate change adaptation and mitigation in the private sector, including relevant state-owned enterprises (SoEs).

In the period 2016 – 2017 covered by this report, the trend of a 16% year-on-year growth in published output on climate change by South African institutions continued, the impact as measured by citation index remained high, as did the cost-effectiveness of research outputs per Rand invested. In this period, nearly 40% of all global research relevant to climate change in southern Africa and its surrounding oceans was conducted by South African institutions. The pattern of dominance by five leading universities continued; together they are responsible for 56% of the published output. A slightly different mix of universities leads in the production of over 100 Masters and doctoral graduates in this field per year.

The first biennial report suggested that national investment in climate-related science and technology (S&T) was in the order of R400 million per year. The more comprehensive funding-source evaluation conducted by the second biennial report indicates that the annual value is closer to R900 million per year. Much of the difference relates to funds mobilised by the private sector (including SoEs) and support from international financial instruments; and it is largely spent on technology development in the climate mitigation space.

There are substantial additional resources invested by the private sector in 'green funds'. While the amounts are in the order of billions of Rands (in total, not per year), in some cases reported data have not been independently verified. There is insufficient information available to assess the share which is climate-related as opposed to that which is being invested on other environmental issues; and within climate, whether it is intended to mitigate climate change or adapt to it. More systematic collection of information on investment and finance by the private sector is required.

Across both the public and private sectors, it is unclear as to exactly what counts as 'climate finance'. South Africa should collaborate with others, including the Organisation for Economic Co-operation and Development (OECD), to understand the financial flows which support climate action, science and technology.

The second biennial report on climate change S&T makes the following recommendations:

¹ The terms of reference for this report use the phrase 'science and technology', which we abbreviate to 'S&T'. We interpret this phrase as synonymous with 'research and development' (R&D); meaning all phases of the process of generating or acquiring new knowledge on topics related to climate change, its impacts and the societal responses to it; turning that knowledge into technologies for climate mitigation and adaptation; and testing those technologies at pilot scale before full deployment.

- Help to raise the overall climate change analytical capacity in Africa by fostering collaboration among research institutions in Africa, particularly between South Africa and other African countries .
- Continue to monitor and evaluate the effectiveness of South African engagement in climate change-related S&T on a regular basis, building on the baseline established by the first and second biennial reports, and introducing metrics which enable the effectiveness of research to be tracked.
- Build on successes in accessing international funding instruments for the support of climate change S&T by preparing project proposals for the several opportunities which are available to South Africa, but not yet used. The DST should publish a register of international funding instruments and disseminate this to research institutions.
- Make maximum use of the apparently high demand for 'green' funding instruments in the private sector.
- Encourage private sector programmes to replace fossil fuel-based energy sources at enterprise level with renewable energy (RE), and include this strategy in ongoing energy sector planning. To date, only a very small fraction of identified opportunities to do so has been realised.
- South Africa should strategically position itself as a world leader in relation to one or a few emerging low-carbon energy technologies. An example is concentrated solar power (CSP), a technology well suited to South African conditions and skills, with the advantage of built-in storage, and where the market does not yet have a clear leader. Other poten-

tial areas could include manufacture of components for RE technologies, and fuel cells, particularly where they require platinum group metals.

- Government should create an enabling environment for small-scale embedded generation and energy efficiency incentives. Urgent attention to this domain is needed, given the rapid change towards smart grids and distributed generation globally, as well as the implications for municipal revenues when customers become suppliers.
- The South African investment in climate-related technologies would be more effective if it were better coordinated across the many individual domains in which it occurs: the energy, water, infrastructure, agriculture and biodiversity sectors, for instance. In some domains, there are potentially contradictory or counterproductive initiatives which should be rationalised.
- South Africa should learn from, and build on, the highly effective role that the Independent Power Producers (IPP) office played in accelerating the deployment of RE. The approach can continue to be effective in that domain and for energy technologies more generally.
- A just transition to a low-carbon and climate-resilient economy and society is a priority. The announcement of a Presidential Climate Change Coordinating Commission to coordinate and oversee the just transition is an important step².
- The advanced S&T capacity which South Africa has in adaptation to climate change, particularly in the context of Africa and developing countries, equip it to play a key role in the Global Commission on Adaptation, launched in October 2018 in The Hague³.



² RSA 2018. Presidential jobs summit: Framework agreement. 4 October. https://www.gov.za/sites/default/files/gcis_documents/Jobs_Summit_FrameWork_Agreement.pdf

³ <https://gca.org/news/global-leaders-call-for-urgent-acceleration-of-climate-adaptation-solutions>



1 INTRODUCTION

Chapter 5 of the National Development Plan (NDP) proposes increased public investment in research and technological innovations to support environmental sustainability and resilience actions of government, business and civil society. In order to address this goal, a number of actions were defined and translated into performance indicators in the NDP's implementation plan for the environment sector; namely Outcome 10 of the Medium-Term Strategic Framework (MTSF) 2014-2019.

The compilation of biennial reports on climate change science and technology (S&T) to the Cabinet of South Africa (SA) is one of the agreed performance indicators. The Department of Science and Technology (DST) is tasked to facilitate the compilation of these reports, working together with the Department of Environmental Affairs (DEA). The DST appointed the Academy of Science of South Africa (ASSAf) to prepare both the first and second biennial reports.

These reports will help ensure that SA has the necessary climate-related knowledge, skills, technologies and capacities to thrive in the 21st century, with all its changes and uncertainties. SA society as a whole, but especially government, needs to know that they are investing wisely and efficiently in order to gain essential human and institutional capabilities to detect, understand, and anticipate climate changes and their impacts; adapt to them; and mitigate further global climate change by reducing greenhouse gas (GHG) emissions in line with stated national intentions. These climate objectives are pursued alongside national development goals. A focus on climate-compatible development would position all sectors of the SA economy and society to be globally competitive in a changing world.

The first assessment was completed in December 2016 (<http://research.assaf.org.za/handle/20.500.11911/66>), and accepted by Cabinet in March 2016. It covered the period 2005 to 2015. This current report is the second in the series. It is an update and elaboration of the first, and assesses climate change-related science and technology (S&T) for the years 2016 and 2017.

This assessment, undertaken between September 2017 and November 2018, was conducted by a panel appointed by the ASSAf Council. Panel members included Prof RJ (Bob) Scholes (Chair), Prof Roseanne Diab, Prof Rashid Hassan, Prof Danny Simatele and Prof Harald Winkler. Biographies of the panel members are provided in Appendix 1.

Information was collated through the following approaches: the review of all relevant and available institutional annual reports; specialist commissioned studies; the extraction of data from national and international databases; and targeted interviews and broad consultation with relevant stakeholders. Research support was provided by Mr Shepherd Mudavanhu, Mr Auke Algera, Dr Jennifer Houghton, Mr Kevin Coldrey and Ms Nadia Algera. Bibliometric analyses were contributed by Ms Maryna van der Heever using the procedure outlined in Appendix 2. Institutions and individuals consulted during the study are listed in Appendix 3.

In November 2018, the draft report underwent stakeholder review (involving 166 individuals representing universities, research councils, government departments and the private sector), through outreach meetings and the submission of written comments. The comments provided have been evaluated and incorporated in the final report as appropriate. The report was approved by the ASSAf Council on 12 February 2019 and submitted to the DST.



2 THE FINDINGS AND GAPS OF THE FIRST REPORT

The key findings of the first biennial report on climate change S&T included:

- The climate change science community in South Africa is productive, effective, and growing. South African scientists and research are well recognised and well represented internationally.
- Investment into climate change-related S&T, largely in the public sector, amounts to roughly R400 million per annum, which has grown at roughly 12% per annum over the decade reviewed (2005 – 2015).
- Even though climate change research is conducted at a large number of institutions in the country, investment and outputs (papers and capacity training) are concentrated in a small number of higher education institutions.
- There is a degree of mismatch between the research priorities identified by research users and in policy documents, and that which is being undertaken.
- There are relatively weak linkages between academic and state-supported climate researchers and the private sector.
- Even though interdisciplinary, multidisciplinary and transdisciplinary approaches are increasingly adopted, there appears to be a lack of partnerships between the broad research disciplines working on climate change (for instance, between the biophysical sciences, social sciences, economics and engineering research).
- Extracting and compiling robust and high-quality information and data on performance and expenditure related to climate change S&T was challenging, and no formal mechanism exists to do so.

The first biennial report self-identified several gaps in its coverage:

Technology development related to climate change (i.e. the bringing of research to market or application in the form of prototypes and pilot projects) was under-represented in the report. It was unclear whether this was because technology development is in fact at a less-than-optimal level, or simply because the approach taken had not revealed it.

Some factors contributing to this gap include:

- Leveraging of international support was not considered.
- Information and data from the non-academic sector, excluding science councils, was incomplete.
- In particular, the private sector was poorly represented, allowing for no valid comparison of investment relative to the public sector.

The current report aims to address the above gaps to the extent possible. As a result, it contains much more material on mitigation-related research than the previous report, which had relatively more material on impacts and adaptation-related research. This does not reflect a sudden swing in the research priorities, nor a preference by the report writers. The two reports should be read together.



3 RECENT CLIMATE-RELATED RESEARCH FINDINGS OF POLICY RELEVANCE

Since the previous biennial report, several findings have emerged from South African and international research which policymakers in South Africa should be aware of.

The Intergovernmental Panel on Climate Change (IPCC) released its special report *Global warming of 1.5°C* (IPCC, 2018). South Africa was among the developing countries which advocated for this report, because of concern that the political 'consensus' reached at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) 21 in Paris of a 2°C limit to global mean warming (with an 'aspiration' to keep it less than this) would expose vulnerable regions to excessive risk.

It is worth noting that a Global Mean Surface Temperature (GMST) rise of 2°C above the pre-industrial GMST translates into an approximately 4°C temperature rise over much of the interior of South Africa. This is confirmed by both climate observations in South Africa over the 20th century (e.g. Kruger, 2013 or Jury, 2018), and by model-based projections for the 21st century (Archer *et al.* 2018).

The IPCC (2018) report shows that the impacts on human health, food security and disaster risk are serious for a GMST warming even of 1.5°C, especially in vulnerable places, which include southern Africa. This confirms much of the impact research done in South Africa. The increase in risk between a GMST warming of 1.5°C and a warming of 2.0°C is very steep. Aiming to keep the world cooler, therefore makes a big difference for countries like South Africa, and should be an international policy priority.

The IPCC report finds that the GMST rise by 2016 already amounts to 1°C. If GHG emissions were to immediately cease worldwide, the inertia of the global climate system would cause the GMST to continue to rise, but it would not reach 1.5°C. Thus, technically it is still possible to stay below 1.5°C, but it is increasingly unlikely that the world will do so, given the delays in implementing steep reductions. If reductions start at once and reach global zero emissions by about 2040, it is still possible to stay below 1.5°C. In practice, it is much more likely that the world will overshoot the 1.5°C target. It can still return to below 1.5°C after that, but only if 'negative emission technologies' are widely implemented by mid-century. No such technologies are yet demonstrated to be economically feasible at the scale needed. Negative emission technologies will also be needed to stay below 2°C. The carbon capture and storage (CCS) experiments in South Africa are an example of such a technology.

It would be prudent policy to plan for the eventuality that the world will exceed 2°C GMST rise this century, possibly quite substantially. This will put huge strain on national water resources and food security. Given that the average temperatures in the arid South African interior could rise by 6°C or more, life there could become very uncomfortable and even life-threatening. Livestock and grain agriculture will become increasingly challenging, especially for small-scale farmers; a consideration of relevance to land reform policies. South Africa has taken a lead in ecosystem-based adaptation strategies, which are appropriate, but by themselves insufficient to reduce the risks to acceptable levels.

On the development side, the announcement of the discovery of a substantial gas resource about 200 km south of Mossel Bay could, if translated into an operational wellfield, help South Africa to meet its emission-reduction goals, partly by replacing coal and oil as fuels, but also by making it possible to increase the amount of solar and wind energy in the South African energy mix.

Finally, in the technology implementation arena, the most recent round of bids for the provision of renewable energy to the South African grid have realised some of the lowest prices anywhere in the world, substantially lower than newly-build coal-fired plants or nuclear energy. Several experimental concentrated solar power (CSP) plants, the result of earlier bids, have recently come on-line in South Africa.



4 CLIMATE CHANGE SCIENCE AND TECHNOLOGY LANDSCAPE IN SOUTH AFRICA

South Africa has a relatively sophisticated, complex and well-established climate-related science and technology landscape as depicted in Figure 1. This depiction is illustrative rather than comprehensive. Many other institutions have some involvement in S&T relating to climate change, and there are linkages not shown here, for the sake of clarity. Almost all South African institutions, in the public, private and civil sectors, are affected by climate change to some degree, either directly or indirectly.

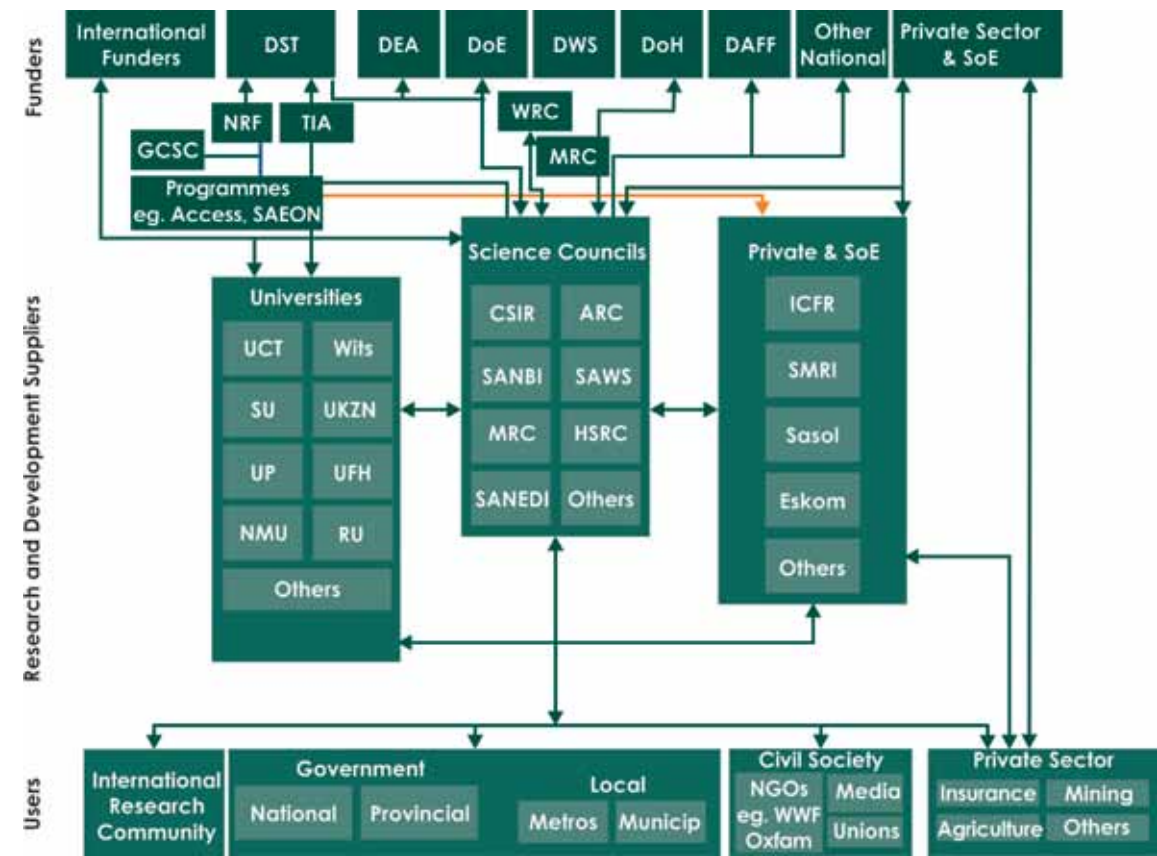


Figure 1. The key institutions involved in funding, researching and responding to climate change in South Africa.

In the first biennial report, a thumbnail sketch of the activities of many of the main players was given. Since these have not broadly changed, it is not repeated here.

Since the publication of the first biennial report, the following changes in the institutional landscape have taken place. In October 2016, the South African Research Infrastructures Roadmap (SARIR) was announced by the Minister of Science and Technology. Of the eleven initial Research Infrastructures (RIs) funded, two are highly relevant to climate change research: the Enhanced Freshwater and Terrestrial Observation Network (EFTEON), and the Shallow Marine

and Coastal Research Infrastructure (SMCRI). Both RIs are hosted by the South African Environmental Observation Network (SAEON) and are in their implementation phase. The two new RIs will significantly increase research capacity in the field of climate change. Several of the other RIs announced in the first group make indirect contributions to climate change research, and further climate-relevant RIs are under consideration.

4.1 Research publications

The output of peer-reviewed publications (principally journal articles, but also including technical books and book chapters, and in some disciplines, refereed conference proceedings) related to the issue of anthropogenic climate change in South Africa and its surrounding oceans, was evaluated for the period 2006 to 2015 in the first biennial climate change S&T report. The second biennial report updates that study, by adding publications retrieved from the major international database Web of Science (WoS) using exactly the same search rules. The outputs relating to southern African climate change published in the years 2016 and 2017 are summarised in Table 1.

Table 1 shows that the largest single contribution to research relating to global climate change as it affects southern Africa and adjacent oceans in the period 2016 – 2017 comes from South African institutions (39.4%, slightly up from the contribution between 2006 – 2015 of 39.0%). The largest contribution in South Africa comes from universities (85%), followed by government-associated research institutions and agencies (12%). Among the universities, the dominance by the top five remains strong. Each contributes nearly 10%; together they provide 56% of the climate-related research output in the country. The next nine universities, which include several formerly disadvantaged institutions, contribute 1% to 4% each, about the same order of magnitude as each of the five research councils and government-linked agencies active in this field. The final 10% of research output was contributed by another 26 institutions. A few of those are non-governmental organisations (NGOs), and only two, in the areas of forestry and sugar cane, are private sector research institutions. Given the relevance of climate change to their spheres of interest, several state-linked research agencies and councils have an apparently low research output as measured by peer-reviewed publications: these are the South African Weather Service (SAWS), Human Sciences Research Council (HSRC), and the Council for Geosciences (CGS).

Table 1. Published, peer-reviewed research outputs in the period 2016-2017 where at least one of the authors was associated with a South African institution.

Institution	Publications		
	2016	2017	Total
University of Cape Town (UCT)	142	150	292
University of KwaZulu-Natal (UKZN)	109	137	246
Stellenbosch University (SU)	106	116	222
University of Pretoria (UP)	90	115	205
University of the Witwatersrand (Wits)	103	96	199
Nelson Mandela University (NMU)	46	44	90
University of Johannesburg (UJ)	34	45	79
Rhodes University (RU)	44	35	79
North-West University (NWU)	33	41	74
Council for Scientific and Industrial Research (CSIR)	35	31	66
University of the Free State (UFS)	34	31	65
University of South Africa (Unisa)	20	32	52
Agricultural Research Council (ARC)	24	20	44
University of Limpopo (UL)	14	23	37
South African National Biodiversity Institute (SANBI)	14	18	32
University of the Western Cape (UWC)	17	12	29
University of Fort Hare (UFH)	9	15	24
South African Institute for Aquatic Biodiversity (SAIAB)	9	15	24
University of Venda (UV)	11	10	21
South African Environmental Observation Network (SAEON)	10	10	20
Tshwane University of Technology (TUT)	9	9	18
South African Weather Service (SAWS)	9	4	13
Council for Geoscience (CGS)	4	9	13
Cape Peninsula University of Technology (CPUT)	5	7	12
eThekweni Municipality	8	2	10
Department of Environmental Affairs (DEA)	3	7	10
African Institute for Mathematical Sciences (AIMS)	7	3	10
Kirstenbosch Research Centre	3	6	9
University of Zululand (UZ)	8	0	8
South African National Parks	5	3	8
Walter Sisulu University (WSU)	2	5	7
Iziko South African Museum	4	3	7
iThemba LABS	3	2	5
South African Medical Research Council (SAMRC)	2	3	5
South African Sugarcane Research Institute (SASRI)	2	3	5
Vaal University of Technology (VUT)	2	3	5
Institute for Commercial Forestry Research (ICFR)	3	2	5
Durban University of Technology (DUT)	3	2	5
Birdlife South Africa	0	4	4

Ezemvelo KZN Wildlife	2	2	4
Human Sciences Research Council (HSRC)	5	3	8
South African National Space Agency (SANSA)	0	3	3
CapeNature	0	2	2
Conservation South Africa	0	2	2
Endangered Wildlife Trust	0	2	2
South African Institute of International Affairs (SAIIA)	0	2	2
All South Africa	988	1 089	2 077
Rest of World	1450	1 747	3 197

The results represent an underestimate of the true output, because not all journals and books are indexed in these databases; and some very important forms of publication (e.g. government reports, or reports published internally by organisations) are not detected by the indexing agencies. The underestimate is small in the natural sciences, but could be stronger in the social sciences. The outcome should not be over-interpreted at the level of individual organisations. The advantage of the approach is that it is objective and consistent. The full details of the search procedure, which replicated that used in the first biennial report, can be found in Appendix 2 of this report.

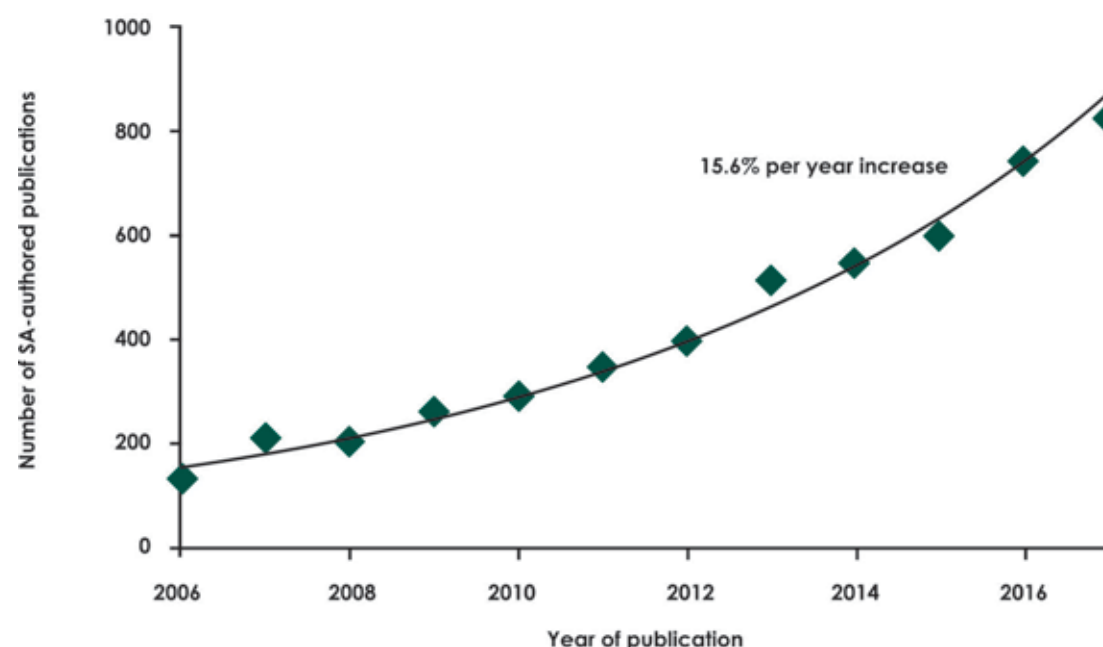


Figure 2. The rate of publication on topics related to climate change by authors affiliated with South African institutions over the period 2006 to 2017.

The year-on-year increase in peer-reviewed, publically-available publications on topics related to climate change by authors affiliated with South African institutions continues at a rate of 15.6% per year (Fig. 2). The results confirm that research output from South Africa in the climate change field continues to increase at a rate which exceeds the rate of increase of research funding dedicated to the field, suggesting a growing research productivity per unit of investment.

The average citation rate for the articles published in 2016 was 5.98 citations per article, and in

2017 was 2.23. It takes a few years after publication for articles to attract citations; the values for 2016 and 2017 are in line with the citation rates recorded in the last two years of the 11-year analysis period undertaken in the first biennial report (i.e. for papers published in 2014 and 2015, when the citation rates were 6.92 and 3.32 respectively). The citation rates in the field of climate change research are high relative to general citation rates in other scientific topics, both nationally and internationally.

4.2 Who else publishes on Southern African climate change?

The climate change field is by its nature highly globalised. South African researchers and research institutions have strong interactions with their counterparts in many parts of the world. The pattern of interactions reveals both historical factors (such as being a former colony of the United Kingdom (UK), which remains a prolific publisher in this field), S&T policy decisions (such as the European South African Science and Technology Advancement Programme (ESASTAP) science cooperation agreement between South Africa and the European Commission, which is reflected in a large published output), and the size of the science capacity in the region analysed (for instance, the interaction with the United States of America (USA) and Canada is relatively strong, probably because of the shared use of English).

By looking at the scientific activity of various regions around the world on the topics which interest us, as revealed by the search strings used to elicit South African publications, we can identify potential gaps in this collaboration policy, which could be filled by science diplomacy in the future (Fig. 3). The biggest obvious shortfall is in relation to Africa. The overall publication rate on climate change in Africa excluding South Africa is low – 8% of the global total. As expected, more interest is shared between South Africa and close neighbours (i.e. countries in the Southern African Development Community (SADC)) than with more distant neighbours (East Africa, West Africa, North Africa). Research topic overlaps with Central Africa are particularly low; this is attributed to a low scientific capacity there. Nonetheless, it is clear that there are areas of shared climate S&T interest between South Africa and the rest of Africa. Therefore further efforts to raise the overall climate change analytical capacity in Africa through collaboration with South Africa are justified.

South Africa shares economic interests with the Brazil, Russia, India, China and South Africa (BRICS) bloc, but the degree of research alignment is relatively low – far below that for OECD countries.

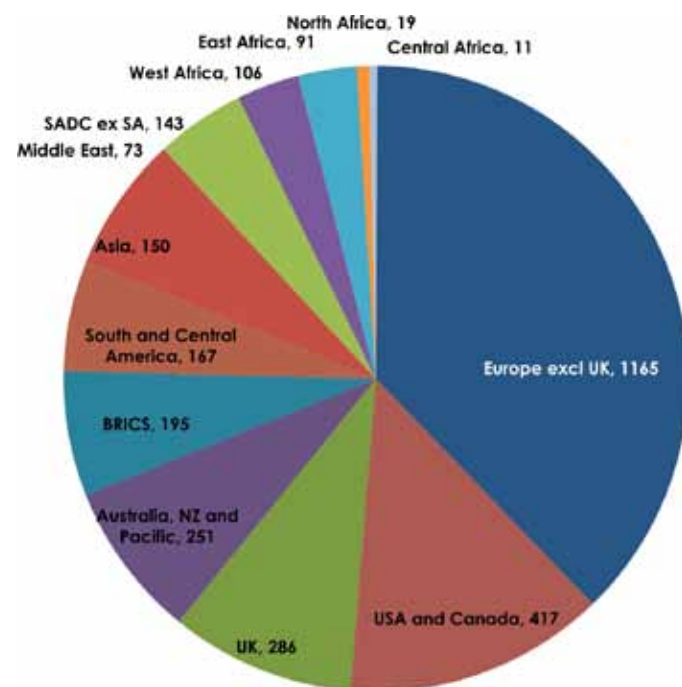


Figure 3. The number of publications generated in the years 2016 and 2017 on the same topics covered by the search for South African publications related to climate change.

4.3 The production of postgraduate researchers

In the period 2016 – 2017, a total of 120 Masters degrees and 104 doctoral degrees were awarded by SA higher education institutions (HEIs) in fields related to climate change research (Table 2). The number of high-level graduates per year (112) is apparently five-fold higher than the 22 per year generated over the period 2005 – 2015, but this is thought to merely reflect the improved quality of the databases used in the more recent analysis.

Table 2. The number of Masters degrees (or Masters equivalents, following the South African Qualifications Authority classifications) and doctoral degrees awarded by South African HEIs in the period 2016-2017 on topics related to climate change.

Institution	Masters		PhD	
	2016	2017	2016	2017
UCT	30	12	12	23
UP	18	4	11	7
RU	8	4	3	12
Unisa	2	5	7	7
CPUT	7	2	1	6
UNIVEN	5	1	0	6
UWC	3	1	4	2
NMU	2	2	0	5
UFH	2	0	2	5
DUT	4	2	1	1

UL	1	1	1	1
Wits	3	0	0	0
UZ	0	1	0	1
TOTAL	85	35	42	76

The data were obtained from the National Electronic Theses and Dissertations Portal hosted by the National Research Foundation (NRF) and every record was evaluated for its relevance to the topic.

In assessing the adequacy of production of human resources with advanced analytical skills in the field of climate change, a number of points must be kept in mind. First, not all graduates in a field end up working in precisely that field. Some graduates change to completely unrelated fields, while using the skills they have acquired. Some emigrate, or cannot work professionally for various reasons. Many, we would hope, work in fields affected by climate change, but without necessarily being scientific researchers. Nonetheless, an annual production of over 100 postgraduates in this field is likely to meet the national need, since it corresponds to a total climate-related S&T workforce of several thousand.

The production of graduates in this and other fields remains racially biased relative to the population proportions in South Africa, and to a lesser degree, gender biased.

Since the first biennial assessment, the following notable engagements by South African, and individual South Africans, research in international research activities have taken place, among others.

- Dr Debra Roberts (eThekweni Municipality) has been appointed a co-chair of the IPCC Working Group II, and a working group technical office has been established in KwaZulu-Natal.
- South Africa hosted an important international Future Earth meeting in Port Elizabeth and the southern Africa regional office of Future Earth is under development at the NRF in Pretoria.
- Prof Scholes co-led the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Land Degradation and Restoration Assessment, completed in March 2018.
- The fifth in the Adaptation Futures international conference series was held in Cape Town 18 – 21 June 2018, for the first time on the African continent. It attracted over 1 300 scientists, practitioners, business leaders and policymakers from around the world.

The participation by South African scientists in international steering bodies and other organs of climate change research remains high (Table 3).

Table 3. South African-affiliated researchers appointed to participate within governance, science or advisory panels or committees of major international climate-related research organisations⁴

Organisation	Number of SA experts	Names
IPCC (Intergovernmental Panel on Climate Change)	13	Albertus J Smit, UWC Sean O'Donoghue, eThekweni Municipality Francois Engelbrecht, CSIR Pedro S Monteiro, CSIR Nicola Stevens, SU, SAEON Mark New, UCT Bruce Glavovic, Massey University Brett Cohen, UCT Sasha Naidoo, CSIR Guy Midgley, SU Christopher Lennard, UCT Gina Ziervogel, UCT Bob Scholes, Wits
WCRP (World Climate Research Programme)	2	Bruce Hewitson, UCT Pedro Monteiro, CSIR
WWRP (World Weather Research Programme)	1	Coleen Vogel, Wits
ISC (International Science Council)	1	Daya Reddy, UCT
IIASA (International Institute for Applied Systems Analysis)	2	Gansen Pillay, NRF Mary Scholes, Wits
GFCS (Global Framework for Climate Services)	1	Witi Jongikhaya, DEA
CLIVAR (Climate and Ocean – Variability, Predictability and Change)	2	Isabel Anson, UCT Bjorn Backberg, CSIR
IGAC (International Global Atmospheric Chemistry)	1	Rebecca Garland, CSIR
PAGES (Past Global Changes)	1	Lindsey Gillson, UCT
SCOR	7	John Compton, UCT Coleen Moloney, UCT Raymond Roman, UCT Katherine Hutchinson, UCT Marcello Vichi, UCT Sarah Fawcett, UCT Lynne Shannon, UCT
GEO BON (Group on Earth Observations Biodiversity)	12	Abel Ramoelo, CSIR Andrew Skowno, SANBI Byron Grant, Strategic Environmental Focus Byron Bester, Digby Wells Jessica Da Silva, SANBI John Wilson, SANBI Krystal Tolley, SANBI Luca Stimimann, UCT Moses Azong Cho, CSIR Nicky Allsopp, SAEON Matthieu Renaud, CSIR Robyn Granger, UCT
GCOS (Global Climate Observing System), Ocean Observation Physics and Climate Panel (OOPC)	1	Marjolaine Krug, CSIR

⁴ A broad interpretation of climate-related organisations is used, but the list should be seen as partial, since there are likely to be some international organisations with some relevance to climate change issues that have not been captured.

IORAG (Indian Ocean Rim Academic Group)	1	Juliet Hermes, SAEON
JCOMM OCG (Joint Technical Committee for Oceanography and Marine Meteorology Observations Coordination Group)	1	Juliet Hermes, SAEON
Argo (Ocean Observing System)	1	Tammy Morris, SAWS
ILTER (Integrated Long-Term Ecological Research Network)	1	Johan Pauw, SAEON
CEM, IUCN (Commission on Ecosystem Management, International Union for Conservation of Nature)	1	Jasper Slingsby, SAEON
AFEC (African Future Earth Committee)	2	Coleen Vogel, Wits Mark New, UCT
iLEAPS (Integrated Land Ecosystem-Atmosphere Processes Study)	1	Sally Archibald, Wits



5 INVESTMENTS IN CLIMATE CHANGE S&T

5.1 Preamble

Sources and levels of funding for R&D on climate change in SA for the ten-year period between 2006 and 2015 were assessed in the first biennial report (ASSAf, 2017). The first report also provided detailed information on the purposes of various international and national instruments available to support R&D for climate change through the provision of funding and other types of assistance, and how SA was linked to and benefited from these instruments. Information on actual levels of funding accessed and used for climate S&T in SA was partial, due to difficulties encountered in acquiring the required data from several agencies. This was particularly true for international sources and the private sector. The first report also did not provide information on the international financial instruments that have subsequently become available as a result of the Paris Accord.

This section of the second biennial report attempts to fill these gaps. ASSAf commissioned two studies to survey sources and levels of investment accessed through climate change international finance instruments and from the private sector. Detailed findings of these studies, together with the methods they used and the sources of the data they collected are provided in Appendices 4 and 5 respectively. The information from these two commissioned studies has been complemented with information from several other sources (including annual reports of companies, SoEs, published official statistics, and personal communications with key informants in public and private agencies).

Information was sourced from both funders and recipients of funding, i.e. implementing agencies. As can be seen from Figure 1, interlinkages between various players in the climate change landscape in SA are complex and multidimensional, as some activities are often funded and/or implemented jointly by more than one agency. As a result, information about several activities have been reported more than once. To avoid double counting, information received from the said sources have been cross-checked and carefully examined before inclusion in our estimation. The combined and summarised estimates of levels of investments in climate change R&D for the 2016 and 2017 years are reported in Table 4 below, where:

- 1 All funds invested are reported by source of the funding and recipient institutions, where information was available. Due to the fact that some implementing agencies receive funding from multiple sources they may be listed more than once.
- 2 A distinction was made between funds used for purely climate change-related R&D or for other purposes. Based on information obtained from the various sources surveyed on titles of projects or description of the nature of the funded activities, a typology has been developed to assist with the required separation of climate change-specific R&D investments from other.

Appendix 4 provides details on sources of the data and basis for our calculations.

5.2 Investment levels and sources for climate change S&T

Funding for investments in climate change-related R&D continues to be sourced from a number of national agencies and international protocols and initiatives. Grants from the national government to several institutions, many of which pass the funding on in the form of competitive grants or subcontracts to other institutions, remain a major source (71% in 2016 and 68% in 2017) of climate-related research funding in the country. The DST continues to be the largest source (about half) of national research funding in relation to climate change (Table 4). Universities and science councils are the main suppliers of the needed scientific research and technological innovations. The private sector, which for this purpose includes SoEs, contributed a significant share of the national investments in climate change S&T (9% in 2016 and 2017), particularly in climate mitigation technological innovation. Private sector investments in climate change S&T are discussed in more detail in Section 6.

The country also invested national public funds in climate change S&T through contributions to bilateral collaborative programmes with other countries. The biggest of these has been the SA-Norway programme (South Africa-Norway Research Co-operation on Climate Change, the Environment and Clean Energy, SANCOOP), which is active mainly in mitigation options in the energy sector. Other collaborative bilateral arrangements included countries from Europe (Poland, Switzerland), Asia (India, Japan), North Africa (Egypt, Tunisia), and several sub-Saharan African countries (Kenya, Mozambique, Namibia, Uganda). More details on projects funded through these bilateral arrangements are given in Appendix 5.

SA was also able to access significant climate change S&T funding (about one-third of total investments during the 2016 – 2017 period) from international sources over the past two years, particularly through multilateral international climate finance instruments (Table 4). More than 80% of the international instrument funding accessed by SA came from the Clean Technology Fund (CTF) (Table 5), which has been used primarily for technological innovations in the energy sector, particularly by Eskom. More details on projects for which these funds have been used are provided in Section 6 and Appendix 6. Funding from foreign sources accessed through bilateral agreements reached more than R20 million during the 2016 – 17 period (Table 4), primarily from Denmark, Germany and other European countries.

Table 4. Sources and levels of investment (R million) in climate change S&T in South Africa, 2015-2017.

Source of Funding	Implementing/Host Agency	2015	2016	2017
GRAND TOTAL		527.58	1 063.84	1 037.32
1 National		439 (83%)	754.36 (71%)	702.87 (68%)
1.1 Public Sector (% of total)		329.75 (63%)	659.35 (62%)	606.42 (58%)
Department of Science and Technology		256.76 (49%)	474.81 (45%)	459.20 (44%)
	ACCESS	16.20	8.42	9.80
	SAEON	14.26	6.91	7.10
	FBIP	10.93	5.30	5.44
	GCSSRD	7.00	3.39	3.48
	RVSCs	6.00	2.91	2.99
	AEON	6.93	3.36	3.45
	SOCCO	9.00	4.36	4.48
	SARVA	3.63	1.76	1.81
	SAASTD	112.69	66.66	69.19
	NRF	39.62	24.68	14.88
	Bilaterals ARC		0.13	0.19
	Bilaterals Other (universities, consultants, etc.)		12.87	3.74
	Socioeconomic Innovations Programme		11.68	10.95
	GCGC Waste Research SARChI's (CSIR)		241.12	223.80
	CSIR	28.00	29.65	31.11
	SANBI	2.50	7.79	10.98
	SAMRC		2.00	1.70
	TIA		66.50	69.00
Department of Energy			(0.5%)	(0.2%)
	SANEDI		5.25	2.25
Department of Environmental Affairs		(9%)	(2%)	(4%)
	SAWS	44.99	19.03	38.85
Department of Agriculture, Forestry & Fisheries				
	ARC		5.04	1.62
Department of Trade & Industry				
	IDC		7.65	6.50
WRC		28.00	3.60	2.30
	CSIR		1.55	0.42
	ARC		0.88	0.24
	Other (universities, consultants, etc.)		1.17	1.64
Other Government (DEA, DE&M, DST, DTI)			144.00 (14%)	95.70 (9%)
	SANEDI		90.37	34.65

	SAWS		0.34	0.44
	Co-finance several programmes with foreign donors		53.29	60.61
1.2 Private Sector including SOEs		110.00 (21%)	94.98 (9%)	96.45 (9%)
ESKOM		50.00	50.00	50.00
SASOL		60.00	30.00	30.00
DBSA	Capital Solutions (Green Fund)		7.50	7.50
VC (Venture Capital)	Several private & public enterprises		4.42	5.89
Anglo American			3.06	3.06
2 Foreign		87.83 (17%)	309.88 (29%)	334.46 (32%)
2.1 Global Instruments		0.00	267.84 (25%)	291.87 (28%)
Clean Technology Fund			262.22	285.78
	Eskom		151.67	163.33
	Several Public & Private Enterprises		110.55	122.45
Green Climate Fund	Capital Solutions (Green Fund)		5.36	5.84
Adaptation Fund	SANBI		0.26	0.25
2.2 Other Foreign		0.00	42.04 (4%)	42.59 (4%)
UNIDO				
	TIA		0.60	0.73
Bilateral from several countries	Several Public & Private Enterprises		20.24	20.24
Belmont Forum (SIDA, Sweden)	Several Public & Private Enterprises		0.25	0.25
Other			20.95	21.37
	SAWS		1.16	1.58
	SANEDI		19.79	19.79

Sources: Appendices 4, 5 and 6, ASSAf (2017), DEA (2018a), SAVCA (2018), SANEDI (2017 & 2018), ACCESS (2017), TIA (2017 & 2018), SAWS (2018), WRC (2018), NRF (2018a & 2018b).

A small share of the international finance instrument funding has been used to support local level resilience and adaptation responses projects through small grants managed by the South African National Biodiversity Institute (SANBI) (Table 4). The SA National Energy Development Institute (SANEDI), which promotes technological innovation, particularly in the energy efficiency and RE area, also enjoyed some support from foreign donors. Other agencies providing climate research services, such as the SAWS, have also been able to access foreign financial assistance (Table 4).

5.3 Use of international climate finance opportunities available for SA

Of the 37 international instruments identified as available to fund investments in S&T for mitigation and adaptation to climate change, SA managed to access funding from only 16 (See Appendix 5 for more details). Information on levels of investment was available only for a subset of the international climate finance instruments. For the six instruments on which we could access information, SA used more than one-third (36.9%) of all the funds approved for the entire sub-Saharan Africa (SSA) region (Table 5). Table 5 also shows that SA, so far, is the only country in SSA to access funds available through the Partnership for Market Readiness (PMR) instrument, which supports the development of national programmes for enabling the use of market mechanisms to facilitate adoption and spread of climate mitigation innovations. This reflects the relative progress made in SA towards implementing market-based policy instruments for promoting low-carbon growth, when compared to the rest of the continent.

It is clear from Table 5 that other African countries invested higher shares of the international instrument funding into adaptation response projects. Particularly in the least-developed countries (LDCs), the favoured projects include the Millennium Development Goal (MDG) Achievement, Smallholder Agriculture Adaptation, and Pilot Climate Resilience programmes. Together these account for more than half of the total funding made available to SSA. Most of the remaining funding approved for SSA went into the protection of carbon reservoirs through conservation of natural forest and reduction of GHG emissions from deforestation and degradation through land use change, in other words, Reducing Emissions from Deforestation and Forest Degradation (REDD) initiatives. Although SA has been the major beneficiary of international climate funding programmes, receiving about 17% of the US\$ 3.53 billion made available for SSA between 2003 and 2017, the country has not been able to use the MDG, carbon finance and REDD international instruments (See Table 2 and Appendix 5 for more details). The fact that South Africa is not on the list of LDC countries, and is not endowed with large natural forest resources, is thought to be the main reason.

Table 5. International funding approved for sub-Saharan Africa (US\$ million) and the share used by South Africa during the period 2003-2017.

International Funding Instrument	Total Approved for SSA	Funds Used by South Africa	
		Amount (% of total)	Funded Projects
Global Environmental Facility (GEF)	384.3	64.10 (16.7%)	Various low carbon & energy-efficient options (e.g. renewables, transport, cities, distribution)
The Adaptation Fund	126.2	9.90 (7.8%)	Small grants enabling local-level resilience and adaptation responses (SANBI)
Green Climate Fund	470.0	12.20 (2.6%)	SCF capital solutions (lower emissions & climate-resilient projects)
Partnership for Market Readiness (PMR)	5.4	5.40 (100%)	PMR SA fostering market-based instruments & readiness to scale up climate mitigation efforts
Special Climate Change Fund (SCCF)	33.5	3.50 (10.4%)	Reducing wildfire hazards associated with climate change

Clean Technology Fund (CTF)	580.2	495.20 (85.3%)	Eskom renewable energy (CSP & wind) and energy efficiency in SA
Total Used	1 599.6	590.3 (36.9%)	
Forest Carbon Partnership Facility Fund (FCPF)	91.9	Not used yet	Forest conservation (Carbon storage) programme
Bio-Carbon Fund Initiative for Sustainable Forest Landscape	26.0	Not used yet	Reducing GHG emissions from deforestation & land use change
Pilot Programme for Climate Resilience (PPCR) I & II	280.6	Not used yet	Integrating climate risk & resilience in development plans
Least-Developed Countries (LDC) Fund	595.1	Not available	South Africa is not a LDC
Forest Investment Programme (FIS)	195.6	Not used yet	Support investments in reducing GHG emissions (REDD+)
Scaling-up Renewable Energy Programme (SREP)	236.8	Not used yet	Low-carbon energy options
Adaptation for Smallholder Agriculture Programme (ASAP)	170.0	Not used yet	Supports policy & private sector engagement, empowerment of women
UN-REDD	29.2	Not used yet	Support investments in reducing GHG emissions (REDD+)
Congo-basin Forest Fund	83.1	Not available	Only for conservation of Congo basin forests
MDG Achievement Fund	20.0	Not used yet	Supports the pursuance of MDGs
Global Climate Change Alliance	205.8	Not available	Helps Small Islands Developing States (SIDS) & LDCs increase their resilience to climate change
Grand Total	3 533.7	590.3 (16.7%)	
Annual investment for SA over the 15 years in US\$ million		39.35	

5.4 Conclusions

The first biennial report estimated a level of investment in climate change-related S&T of more than R500 million in 2015. This investment level has doubled to reach more than R1 billion in 2016 and 2017. This is primarily due to capturing information on investments by other players not included in the first biennial report, particularly work funded by foreign sources and the private sector. Public national sources of funding contributed about two-thirds of total investments in climate change S&T during the 2016 – 2017 period, the bulk of which was through the DST, with a share of 9% from the private sector. Over the same period, South Africa was able to access more than R300 million per year from foreign sources of funding, mainly supporting climate change mitigation efforts. There is, however, a large potential for more external funding through other global finance instruments that are not yet utilised. This could be one area where some more research effort is needed to investigate causes of failure to tap such sources.

6 CLIMATE SCIENCE AND TECHNOLOGY IN THE PRIVATE SECTOR

6.1 General introduction

The first biennial report (ASSAf, 2017) had a very limited treatment of the private sector activities, stating that Eskom, Sasol, the Sugar Milling Research Institute (SMRI), the Institute for Commercial Forestry Research (ICFR) and the National Business Initiative (NBI) undertake some climate-relevant S&T activities⁵, and noting “virtually no discoverable publications”. The identification of the weakness in coverage of the private sector led to a commissioned study for the second biennial report (Appendix 6), which was the main source of information for this chapter.

6.2 Focus areas for the private sector

6.2.1 Financing mitigation and adaptation

The finance available to the private sector and SoEs for climate change activities has largely focused on mitigation, for which it is easier to establish a return on investment, than is the case for climate adaptation. The return can result either through the generation and sale of RE , or through energy savings from increased efficiency. A substantial component of this funding is available through international donor funding agencies, such as the World Bank, the Global Environmental Facility (GEF) and the United Nations (UN). Funding made available to the private and SoE sector from these three sources from 2003 to 2017 is estimated at around US\$520 million (R7.6 billion) (Appendix 5). It was primarily focused on promoting clean energy technology. Examples include:

- **The World Bank’s Clean Technology Fund** (\$495m (R 7.2 bn), 95% of the total \$520m above) which was part of a much larger World Bank loan (\$3.5bn) for the construction of the Medupi and Kusile coal-fired power plants. The funds were made available between 2003 and 2017. The Clean Technology Fund includes the following projects:
 - Eskom’s RE Support Programme for CSP and wind
 - The South African Sustainable Energy Acceleration Programme
 - The South African Energy Efficiency Programme
- **The GEF** (\$13m (R 0.19bn), 2.5%) which includes the following projects:
 - The United Nations Industrial Development Organisation (UNIDO) Cleantech Programme for small and medium enterprises in South Africa
 - Industrial Energy Efficiency Improvement in South Africa
 - Organic Waste-to-Energy and other Low-carbon Technologies in SMEs
- **The UN’s Green Climate Fund** (GCF) which includes a grant made to Strategic Climate Fund (SCF) Capital Solutions (\$12m (R 0.17b), 2.3%) to enable them to offer short-term working capital finance to SMEs involved in green and environmental sustainability supply chains and projects, specifically those companies with goods or services aimed at mitigating climate change. So far, financing has been concluded to 35 SMEs, resulting in over 13 000 tonnes of CO₂ emissions reduction per year.

⁵ In this report science and technology (S&T) is considered synonymous with research and technology development (R&D).

Apart from these international donor funding institutions, finance is also available through a Green Fund managed by the Development Bank of Southern Africa on behalf of the DEA (DEA, 2016a). The Green Fund is a R800 million funding facility, available to either private or public institutions. Types of funding for the private sector include loans (at concessional rates and terms) and equity. Funded projects in the private sector include organic waste treatment to energy and energy efficiency projects. The newly-established Climate Finance Facility in the Green Fund is not yet operational. It will use its capital to fill market gaps and crowd-in private investment, targeting commercially viable technologies that cannot currently attract market-rate capital at scale and will focus on infrastructure projects that mitigate or adapt to climate change (DEA, 2016a). The Technology Innovation Agency (TIA) funds the Climate Innovation Centre South Africa (CICSA). CICSA supports 34 companies in an early stage of development and which focus on the energy, waste and water sectors (Innovation Hub, 2018).

Government has developed a number of incentives to promote climate mitigation activities in the private sector. These include tax incentives for companies implementing energy efficiency and Clean Development Mechanism (CDM) projects, as well as an accelerated depreciation allowance for investments in RE and biofuels production (Van Aarle, 2010). Other incentives include a levy on incandescent lightbulbs to incentivise the switch to more energy-efficient options, a tax on carbon emissions by vehicles to incentivise the switch to fuel-efficient vehicles, a levy on electricity consumption from non-renewable sources, and the long-awaited carbon tax and associated carbon offsetting regime (Van Aarle, 2010).

The City of Cape Town is currently considering the best means for regulating and incentivising energy efficient developments which will contribute to the city's strategy to achieve net zero carbon for all new buildings by 2030 (Van Rensburg *et al.*, 2018). One such measure under investigation, is a municipal financing scheme along the lines of the international Property Assessed Clean Energy (PACE) programme that offers energy efficiency financing which is repaid as an assessment on the property's rates bill (Muringathuparambil, 2018).

In many instances, the high initial cost to the private sector of implementing RE generation and energy and water efficiency projects on-site has led to innovative finance solutions by energy services companies. For example, tailored solutions where capital repayments are made out of energy and water savings are helping to fast-track project implementation.

Although these financing facilities and government incentives have played a major role in the development of climate mitigation projects in the country, there is still a substantial financing gap for which a number of investment managers have developed specific financial vehicles to attract retail and institutional finance. These funds invest in RE projects, however, the share of the total fund size invested in RE and other climate-related investments is unknown. In the following list of funds, the values reflect total fund sizes, which include other infrastructure investments, such as toll roads:

- Nedbank's Green Savings Bond (fund size unknown; ~R8bn to end-2013).
- Old Mutual's Infrastructural, Developmental and Environmental Assets (IDEAS) Fund (fund size unknown; ~R8bn to end-2016).

- Africa Infrastructure Investment Managers (AIIM)⁶ – Old Mutual subsidiary – African Infrastructure Investment Fund (~R19.2bn).
- AIIM – Old Mutual subsidiary – African Infrastructure Investment Fund (AIIF) 2 (~R7.9bn).
- AIIM – Old Mutual subsidiary – Apollo Fund (~R0.7bn).
- Vantage Capital's Green-X Fund (~R5bn).
- Prescient and the World Wide Fund's (WWF) Living Planet Fund R0.8bn as at 31 August 2018
- Growthpoint Properties' Green Bond, the first Johannesburg Stock Exchange (JSE)-listed green bond (R1.1bn).
- The City of Cape Town and City of Johannesburg Green Bonds (R1bn and R1.5bn, respectively). The City of Cape Town's Green Bond has been accredited by the Climate Bonds Initiative.

Taking the World Bank funds, private sector investment and financial vehicles together adds up to R 61bn; the largest share (31%) of this is from AIIM AIIF of R19bn; with three others between of 12 – 13% (R7 – 8bn) each – the CTF, Nedbank Green Bonds and IDEAS fund. However, it is important to note that these are total fund values and the share invested in climate-friendly technology is not known. Furthermore, some investments are reported not annually, but over longer periods, adding uncertainty to the total. Therefore, the totals should not be understood as all climate-friendly investment. While the total amounts are in the order of billions of Rands, there is insufficient information on the share of investment that is climate friendly as distinct from increasing emissions; lack of clarity on annual or longer time periods; and in some cases data reported have not been independently verified. More work is needed to understand 'climate finance', both internationally and in South Africa.

Furthermore, to assist South African investors and investment managers in mitigating carbon risk in their portfolios, Standard and Poor developed the first carbon price risk adjusted index for South Africa in 2018. This is an important step, since the failure of a director to consider climate risks to the profitability and long-term sustainability of a company could be interpreted as a breach of a director's fiduciary duty under South Africa's existing legal framework (Reddell, 2018).

In the venture capital (VC) arena, the total amount invested by VC funds in all arenas is R4.39bn, of which only 8.6% of investments are in the climate change-related sectors of energy and agriculture (6.7% in the energy sector and 1.9% in the agriculture sector; Fig. 4). However, only 5.9% of companies use VC to fund S&T spending, according to a venture capital survey (SAVCA, 2018).

⁶ Information on Old Mutual's Africa Infrastructure Investment Managers – AIIM funds can be found on the website, www.aiimafrica.com

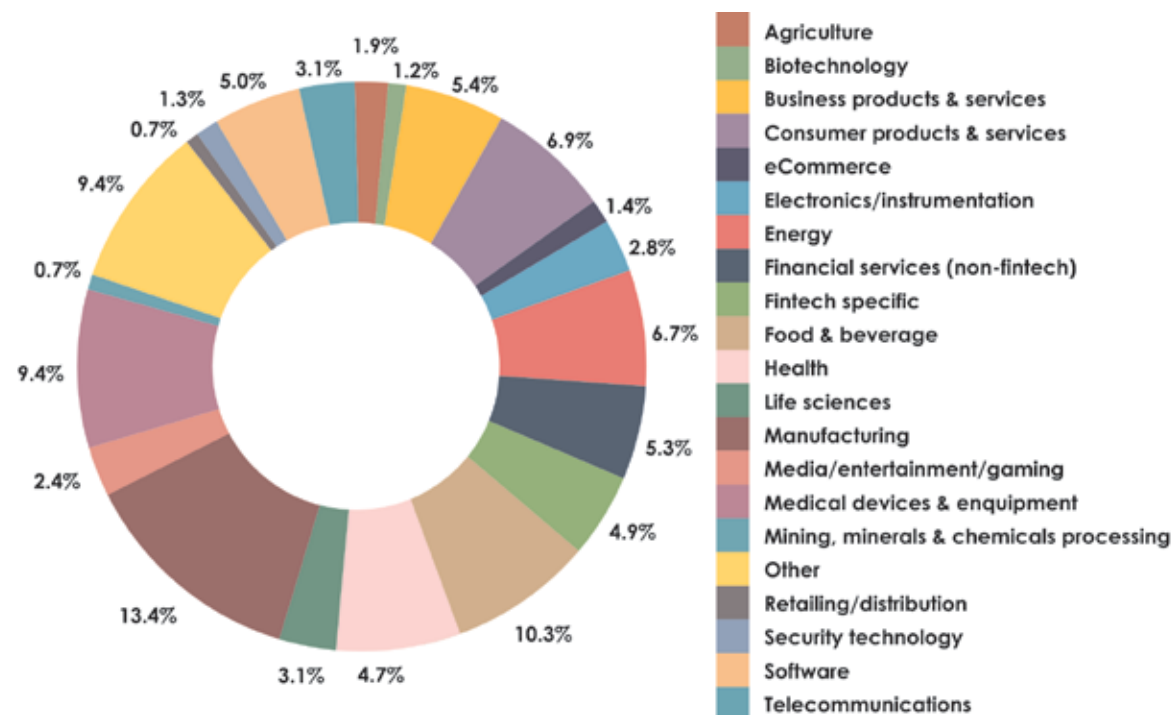


Figure 4. Allocation of venture capital funds in South Africa to sectors, by value of deals (SAVCA 2018).

6.2.2 Financial disclosure and voluntary reporting

According to the 2017 Carbon Disclosure Project (CDP) report on progress in climate reporting, South African companies, which have been global leaders in providing data to the CDP for the past decade, may be beginning to falter. In the past, all responding South African companies disclosed scope 1 and 2 data and 91% disclosed two or more scope 3 categories. Data for 2016 and 2017 point to a slowdown in progress (CDP, 2017). When comparing South Africa's response to the other CDP samples in the world, reporting by companies now falls in the middle-to-end of the range. While 82% of South African companies set emissions reduction targets, this is tenth out of CDP's total of 27 global samples. Absolute emissions reduction targets were set by 44% of South African respondents (15th of 27). Under three-fifths of South African companies report having products or services that enable third parties to avoid GHG emissions (25th out of 27). Four-fifths of all targets are set to expire before 2020 and only 58% of companies that integrate climate change into risk management consider timelines beyond six years. Although there is a drop off in the companies scoring in the A category (the top category in the CDP reporting framework), down from 37% in 2016 to 28% in the JSE top 100 companies sample, and 20% in the full sample, South Africa's distribution of performance scores is still positive, with the majority of companies scoring in either the A or B categories.

6.2.3 Mitigation and adaptation activities

The mobilisation of finance for RE and efficiency projects, coupled with the declines seen in RE technology prices (See Section 6.3.1), has led to a fast-growing energy services industry in South Africa. As a result, legislation has often struggled to keep pace. The substantial decline in solar photovoltaic costs has resulted in strong demand from the commercial and

industrial sectors which, combined, represent nearly 70% of all new solar rooftop installations (Muringathuparambil, 2018).

Based on over 1 000 on-site surveys conducted through the NBI's Private Sector Energy Efficiency Programme (PSEE) from 2013 – 15, 21 896 GWh of lifetime energy savings were identified in the private sector (NBI, 2015). Of the roughly 6 000 opportunities identified, 796 were implemented during the programme's lifetime (2013 – 2015), resulting in 646 GWh of lifetime energy savings. From this assessment, it can be seen that much is still to be done in the private sector. In fact, according to the NBI, 6.8 million tonnes CO₂e were saved through emissions reduction activities in 2017, down from 7.5 million in 2016, indicating a slowdown in private sector mitigation activities (NBI, 2015).

In terms of adaptation, many companies who are at risk of climate change impacting on their operations are investing in adaptation research. An example is Anglo American, who report that about R17m has been spent on various studies that focus on adaptation to climate change. These include technology development to be able to continue mining without the use of water (Appendix 6). The NBI has compiled a report showcasing a number of South African companies that have integrated adaptation planning into their existing risk management processes and supply chains (NBI, 2017). These companies have also built clear adaptation strategies based on robust data and established partnerships to help them implement the strategies. Here are some examples taken from the report:

- Woolworths' Farming for the Future initiative arose from a growing concern regarding the sustainability of their fresh produce supply chain sparked by a decline in crop yield and quality from their supplying farms. Woolworths recognised that in the context of rising demand, existing environmental pressures and projected climate changes, high-quality, high-yield produce can only be achieved by adapting current farming practices to improve soil and water management, as well as facilitating crop selection for resilient varieties in specific areas. This resulted in the Farming for the Future initiative, which provides guidance to producers.
- Distell has identified how changes in climate will require the planting of 'new' grape cultivars in South Africa that are more drought and disease-resistant. This could result in new market opportunities.
- FirstRand has identified opportunities to shift property financing as a result of current changes in precipitation and seasonal weather patterns. Specifically, FirstRand's commercial agricultural finance division has noticed a growing trend towards the purchasing of property in the north-western regions of South Africa by wine farmers, a shift linked to changes in temperature ranges in the current wine producing regions of South Africa.
- Eskom has been working with the CSIR to determine the impact of climate change on all their sites and infrastructure across Southern Africa. This included the identification of especially vulnerable areas. Eskom then commissioned research studies to understand the full risk profiles and implications in these areas. Eskom partners with government, the private sector and other stakeholders on many climate adaptation topics, including water supply and water demand management, energy efficiency projects, biodiversity and natural resources management, weather forecasting and reporting, as well as innovation and technology development.

Adaptation requirements are already imminent in the infrastructure sector. Climate impact assessments are now part of some environmental impact assessments. In a landmark case in 2017, Earthlife Africa and the Centre for Environmental Rights won a High Court case that

resulted in the private developers of a new coal-fired power station in South Africa being required to complete a climate impact assessment (CER, 2017). The High Court referred the matter to the Minister of Environment. The DEA noted that a climate change impact assessment had commenced, but maintained that the planned mix of power generation technologies in South Africa included coal (DEA, 2017). On this basis, the Minister issued an environmental authorisation, allowing the coal-fired independent power producers projects to go ahead. It is not clear whether funders, including South African banks, will continue to support the project (Yelland, 2018).

6.2.4 Technology and product development

There are few examples of climate-smart technology development by the private sector in South Africa, where the practice has largely been to implement or resell existing technologies. However, there are examples where companies are investing in research into new energy-related products. Several mining companies are doing research on how the materials which they mine can be used to transition to a greener economy (See Section 6.3 for more details). Examples outside of the energy sector, include the following from the agriculture sector:

- Beginning in 2010, wine and table grape farmers in the Western Cape started to reap the benefits of satellite-derived information through the GrapeLook initiative, which allows them to improve their on-farm water use efficiency. Today this initiative is known as FruitLook. It provides data for an area of over 9 m ha, planted with many different crops, with weekly updates on crop growth, real crop water use and plant nitrogen. Over 71% of the users indicate they have improved their water management as a result, a critical factor in weathering the droughts of 2016 – 2018.
- The Confronting Climate Change (CCC) initiative is a carbon foot-printing project, developed to support the South African fruit and wine sectors. The CCC includes an online carbon foot-printing platform; a series of regular industry engagement workshops; a range of commodity-specific industry benchmark reports; and up-to-date and relevant energy and emissions-related news and information. There are currently 1 500 users and around 702 businesses with completed assessments.

6.2.5 Research and projects

The private sector has invested in considerable climate change research. According to an annual survey on R&D expenditure in South Africa by the Centre for Science, Technology and Innovation Indicators, the gross domestic expenditure on research and experimental development (GERD) was R32.3 bn in 2015/16 in South Africa. The business sector funded 38.9% of total expenditure in 2015/16. Investments in Green R&D accounted for R8.2 bn or 25.45% of total R&D expenditure. The private sector performs 41.2% of all Green R&D activity. Climate change-related R&D only forms a subset of Green R&D and the specific numbers for climate change-related R&D could not be obtained for this study.

The insurance and engineering sectors are most active in the field. The insurance sector uses climate impact modelling to better understand the risk that their clients encounter in the face of climate change. Insurers are being called upon to respond to increasing numbers of property claims. As a result, the industry is reassessing its risk appetite and applying climate-sensitive risk models to accommodate the additional risks. Santam, the first African member of ClimateWise, has spearheaded the Santam Partnership for Risk and Resilience (P4RR) programme, which focuses on ten vulnerable district municipalities and 53 local municipalities.

Risk-reduction interventions include, for instance, supplying local fire stations with equipment. Other measures include improving flood defences, contributing towards better building plan approval processes and updating flood risk maps. In response to lessons learned from recent disasters, such as the Knysna fires, Santam is also partnering with communities to proactively manage risk.⁷

6.3 Energy sector research related to climate change

6.3.1 Renewable energy

The rapid expansion of RE technologies reported in the first biennial report has continued with the RE Independent Power Producer Procurement Programme (REI4P). Over four bid windows between 2010 and 2018, the REI4P has mobilised over R200bn of total capital, of which R48.7bn (24%) is foreign direct investment (IPP office, 2018). Financial closure was delayed for a period of two years, but in March 2018, it was announced that 27 projects in windows 3.5 and 4 would be signed in April 2018. In total, 6 422 MW of RE capacity has been procured from 112 IPPs. Of this installed capacity, 3 776 MW has been connected to the national grid, generating 24 913 GWh in total, and 9 255 GWh over the last 12 months (IPP office, 2018). This corresponds to about 4.2% of the electricity generated by Eskom, reported as 221 936 GWh per year (Eskom, 2018). Most of the installed capacity actually procured has been in wind (52%) and solar photovoltaic (36%) technologies, with CSP making up 9%. A strategic long-term investment in CSP should be considered in South Africa, as this technology has advantages of built-in storage (it is noted that this is receiving attention at Stellenbosch University (SU). Other countries have already dominated the market in leading in wind and photovoltaics. Another strategic investment opportunity could be to produce components of RE technologies in South Africa. For this to be realised, it is critical to have long-term policy certainty regarding the future energy mix.

The mitigation effects of the REI4P from inception to March 2018 are reported as 25.3 Mt CO₂ reduced. The water savings of 29.9 million kilolitres are relevant to adaptation (IPP office, 2018). SAEON released a Bioenergy Atlas in March 2017; some aspects of their Risk and Vulnerability Atlas are also relevant here.

The IPP office for procurement established by the Department of Energy, National Treasury and the Development Bank of Southern Africa, is widely acknowledged to have played an important role in the success of the REI4P. The efficient and productive relationship between government and the private sector (in this case, RE project developers) is a model that could be extended to other procurement processes.

The costs of renewable energy technologies have fallen dramatically, globally and in SA. They have passed the key tipping point of being cheaper than coal or nuclear plants on an installed capacity basis (in units of \$/kW). However, there is a legitimate concern that this does not reflect the intermittency of RE sources. Making the comparison in terms of USDc/kWh, takes the intermittency into account and provides a better comparison.

Globally, investments in new RE capacity now exceed those in fossil-based electricity generating technologies, with most installation in emerging and developing countries (IRENA, IEA & REN 21, 2018). Technology learning (both innovation and economies of scale) are a function of global cumulative installed capacity (Ibenholt, 2002; IEA & OECD, 2000; Nemet, 2006). Prices for renewable energy technologies continue to decline worldwide, to as low as below

⁷ www.santam.co.za/about-us/media/specialist-business/risk-management-in-a-changing-climate/

3 USDC/kWh in a recent Dubai auction (Kruger & Eberhard, 2018). Figure 5 shows the rapid fall to around 5 USDC/kWh in successive bid windows in SA (Kruger & Eberhard, 2018).

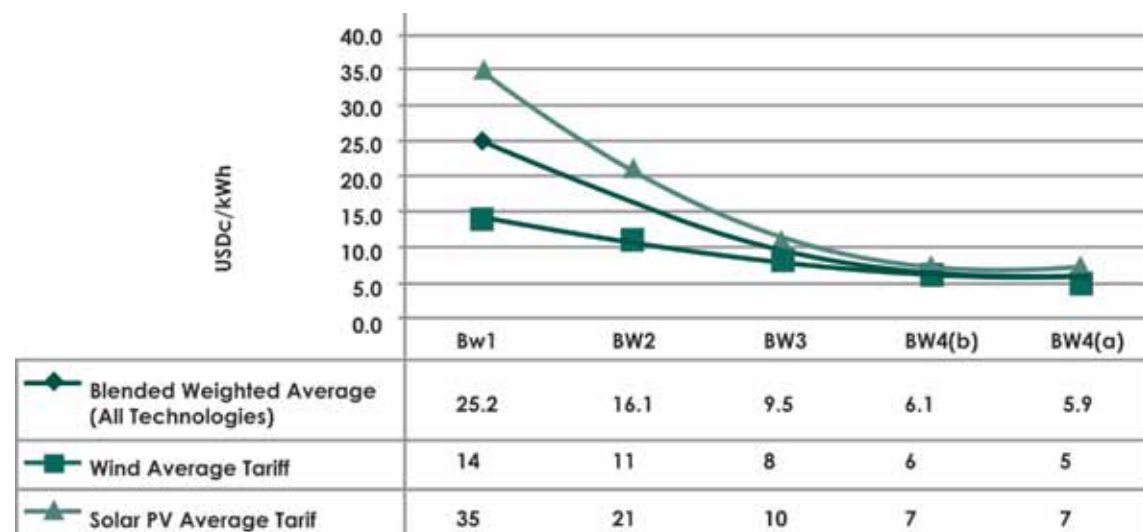


Figure 5. Tariffs for wind, solar PV and all RE technologies across four bid windows in REI4P. (Source: Kruger & Eberhard, 2018)

While the REI4P has seen very significant private sector investment in RE, there has been relatively little local S&T. The REI4P has created 35 702 job-years for South Africans, (IPP office, 2018). While the first bid window saw a larger share of locally-owned companies, the later rounds have seen international firms take larger shares of a rapidly growing market. There has been a requirement for RE project developers to invest in socio-economic benefits, with a 30% weighting on a list of social criteria and 70% on cost (rather than the usual 90%). The reality of community benefits requires further investigation, beyond a single PhD thesis (Wlokas, 2017). Nevertheless, socio-economic development contributions total R574m to date, with additional contributions to enterprise development (IPP office, 2018). The issue of community-owned renewables has been raised as part of a debate around a just transition to a low-carbon economy (Overy, 2018), and the broader question of transitions and their political economy (Baker & Phillips, 2018; Burton *et al.*, 2018; IRENA *et al.*, 2018; Overy, 2018).

6.3.2 Nuclear energy

Nuclear power has seen few developments in research and innovation since the first biennial report. The previous report noted different treatments of nuclear power, with South Korea considering it part of green growth, while Germany planned to phase nuclear power out of its mix. In SA, debates about building nuclear power (beyond the one existing station at Koeberg) have been largely political. A total of 9 600 MW of nuclear power were included in the IRP 2010 (DoE, 2011) and key considerations were whether these would be procured from Russia, China or other vendors. The plan recommended in the draft IRP 2018, still undergoing public comment, does not include new nuclear capacity and envisages decommissioning of Koeberg by 2045 – 47 (DoE, 2018).

A world nuclear industry status report points out that building of new nuclear plants after Fukushima remains slow. Nuclear power generation increased in China, but declined in the rest of the world. Four reactors started up in 2017, three in China and one in Pakistan. The number of units under construction globally declined for the fifth year in a row, from 68 reactors at

the end of 2013 to 50 by mid-2018, of which 16 are in China. China spent a record \$126bn on renewable energy technologies in 2017. Relevant to plans to decommission Koeberg is the global finding that of 115 units undergoing decommissioning, only 19 have been fully decommissioned, of these only ten have returned to greenfields sites (Schneider & Froggatt, 2018).

6.3.3 Coal

Given that coal technologies have been developed over many decades, much of learning and innovation took place in the 20th century. However, with the challenge of climate change, R&D into reducing GHG emissions from the coal value chain is needed if this fuel is to remain relevant.

The coal value chain includes coal mines, use of coal in power plants (Eskom), coal-to-liquids (CTL) facilities (Sasol), and direct use in industry. Three sectors have particular challenges in this regard: the electricity sector; the liquid fuels manufacture sector; and the basic iron and steel industry. Together, these three sectors account for more than 80% of domestic coal demand in terms of value and approximately 70% in terms of volume (Chamber of Mines, 2018). Eskom, Sasol and steel companies such as Arcelor Mittal may soon have to comply with company-level carbon budgets under a climate law (DEA, 2018) and pay a carbon tax for GHG emissions above their budget (National Treasury, 2017). One focus by industry is on high-efficiency and low-emissions technologies. Existing coal-fired power plants are based on a steam cycle dubbed 'sub-critical'. New super-critical or ultra-supercritical plants have marginally higher efficiencies. Potentially larger gains in efficiency can be obtained through integrated gasification combined cycle (IGCC). There are very few IGCC plants in commercial operation globally, despite research since the 1960s in the US.⁸

Sasol operates the only CTL plant at Secunda. Most of its GHG emissions are due to the CTL process. Sasol voluntarily reported 59.2 Mt CO₂-eq of Scope 1 emissions in South Africa (CDP, 2017), i.e. without emissions from electricity use or global operations. This makes up 11% of the total South African GHG emissions, including sinks, of 518 Mt (data for 2012, the latest available) (DEA, 2016b). Other large point sources are coal-fired power plants, collectively accounting for about 42% of national total emissions.

CCS has been investigated internationally. An IPCC special report on the topic was issued more than a decade ago (IPCC, 2006). Nevertheless, the second biennial report has struggled to determine the state of CCS S&T in South Africa, though some information has been gathered. Anglo American, Glencore, BHP Billiton and Sasol all report undertaking research on CCS, and see it as a new business opportunity (Appendix 6), even though it imposes an energy penalty. An energy penalty means that less energy is sent out from a plant with CCS than the same plant without CCS. The literature reports an absolute lower bound for the energy penalty of around 11%, while a 'decent target value' is around 29% (House *et al.*, 2009) (See also IPCC, 2006). Anglo American reports that it invested approximately R130m in research on cleaner coal technology, though it is not stated over which period. The company also makes a small investment (R650 000) in SA in a project exploring CCS mineralisation in kimberlite and plans a larger investment, reportedly R29m, into this project (Appendix 6). SASOL has indicated that they have spent between R50 and 70 million in the last two years on climate change-related research; "mostly" in South Africa (Appendix 6). There is no systematic mechanism for collecting information on investments in R&D by companies, nor are the data verified by independent third parties.

⁸ <https://www.netl.doe.gov/research/coal/energy-systems/gasification/gasifiedia/project-examples>

The Department of Energy has joined an international Carbon Sequestration Leadership Forum and has established the South African Centre for CCS (Beck *et al.*, 2013). DST/NRF funds a South African Research Chair Initiative (SARChI) Chair of Clean Coal Technology, hosted at the University of the Witwatersrand (Wits), and an atlas of potential geological CCS sites has been produced (Council for Geoscience, 2010).

Diversifying the energy mix has been a goal of SA energy policy since 1998 (DME, 1998). Climate change has made a shift away from coal and into lower-carbon energy sources urgent. In that process, it is critical to consider a just transition that would ensure that communities and workers dependent on coal find new livelihoods, a topic in several recent studies locally and internationally (Burton *et al.*, 2018; Spencer *et al.*, 2018).

6.3.4 Gas

Gas has lower GHG emissions than coal at the point of combustion. However, the unintended leakage of the main component of natural gas, methane, into the atmosphere can offset the emission reductions. Management of fugitive methane has been explored in relation to shale gas fracking (Winkler *et al.*, 2016) as part of a scientific assessment (Scholes *et al.*, 2016). SA's technical readiness for hydraulic fracturing has been considered in an ASSAf report (ASSAf, 2016). Early estimates of the total available unconventional gas resource in the Karoo were highly uncertain, and have been consistently reduced in recent years. A drilling project in 2017 found "no desorbed and residual gas, despite high total organic carbon value [and that gas] to be metamorphosed and over-mature" (De Kock *et al.*, 2017). In plain language, the gas in the Karoo may have been 'cooked' and not much may be usable. The study deflates resource estimates to 13 tcf and suggest that, to be economically viable, the resource would be required to be confined to a small, well-delineated 'sweet spot' area (De Kock *et al.*, 2017).

If these findings are confirmed by further studies, the strategic consideration of gas can be expected to shift from shale fracking to liquefied natural gas (LNG). Floating storage regasification units (FSRU) can import LNG without investment in onshore regasification infrastructure. However, it is widely expected that imported LNG prices would be higher than those for domestically-sourced shale gas. The use of gas can help balance the intermittency of solar PV and wind until storage options such as batteries become more affordable. It is also worth noting that using gas for gas-to-liquids would be inefficient compared to using compressed natural gas (CNG) directly in vehicles.

As part of the government-led Operation Phakisa, offshore oil and gas exploration has been prioritised. Government is working towards creating an enabling environment that will give the private sector the certainty required to invest in this capital-intensive sector. The offshore oil and gas work stream of Operation Phakisa has developed 11 initiatives to fast-track the ambitious target of drilling 30 exploration wells in ten years.

6.3.5 Energy storage

The University of the Western Cape (UWC) hosts an Energy Storage Innovation Lab (ESIL), funded by DST, and with industry partners. Focal areas of technology development include proton-exchange membrane fuel cells, solid polymer electrolyte electrolyzers, new hydrogen storage materials and related technologies, and lithium-ion batteries. These activities together with future research, development and innovation can be expected to support a possible

hydrogen economy and provide critical storage for the rapidly growing renewable energy industry, particularly through Advanced Battery Technology.

Both fuel cells and distributed RE systems have the potential to contribute to future grids, but also energy used in commercial and residential buildings, and in transport when combined with electric vehicles. Electric vehicles, if they reached significant penetration in the South African market, would constitute forms of distributed storage that require further research and strategic consideration. Battery pack costs are reported to have fallen internationally from around \$1 000/kWh in 2010 to around \$200/kWh in 2018. \$100/kWh is thought to be the tipping point where the costs for electric vehicles and conventional internal combustion engines are similar.⁹

Combined with the potential for buildings – offices, industrial facilities, residential homes – to have their own storage devices, future energy systems might be far more decentralised than the current South African pattern of central electricity generation and fuel from six refineries.

Tests are being conducted at the Eskom R&D centre on the suitability of battery technologies for the South African environment and the Eskom grid. Currently three very large batteries are already installed. (Appendix 6).

The Industrial Development Corporation (IDC) does not invest directly in research, but does have a New Industries Strategic Business Unit. This business unit invests in eight different industries that have the potential to make a significant impact on SA. Four of these are climate change-related: Energy Storage; Gas Beneficiation; Renewable Energy Inputs; and Fuel Cells. Since April 2017, the IDC has invested more than R13m in energy storage, and more than R136m in RE inputs. No recent investments in fuel cells could be found; however in 2015, IDC invested R15.3m in S&T to develop a practical and workable fuel cell (Appendix 6). Furthermore, the IDC has collaborated with the private sector to promote the local production of vanadium redox flow batteries, such as the collaboration with Bushveld Energy, a subsidiary of the vanadium miner, Bushveld Minerals. The scope of this collaboration includes a manufacturing facility in East London for vanadium electrolyte and the development of a utility scale vanadium redox flow battery with support from Eskom (Appendix 6).

6.3.6 Fuel cells and the hydrogen economy

South Africa accounts for 96 per cent of known global reserves of the platinum group metals (PGMs), 74 per cent of chrome, 26 per cent of manganese, 26 per cent of vanadium and 11 per cent of gold reserves (DMR, 2015). Platinum is an excellent catalyst in fuel cells. Developing a local fuel cells manufacturing industry is part of the Department of Mineral Resources' (DMR) strategy (DMR, 2017) and the Department of Trade and Industry's (the dti) industrial policy action plan. Implats deployed a fueling station with locally developed metal hydride compressors, and Isondo launched a fuel cell plant in Cape Town (the dti, 2017). Anglo American invested R7m between 2014 and 2016 in fuel cell-related research programmes. The Mineral Council of South Africa (formerly the Chamber of Mines) has installed a 100 kW fuel cell to provide power to its offices¹⁰.

⁹ <http://www.engineeringnews.co.za/article/lithium-ion-batteries-energy-storage-on-strong-demand-growth-trajectory-2018-08-13>

¹⁰ www.mineralscouncil.org.za/special-features/87-the-chamber-celebrates-the-first-anniversary-of-its-fuel-cell

6.3.7 Small-scale embedded generation

The National Planning Commission (NPC) has noted that “there is currently a very small-embedded generation market in South Africa” (NPC, 2018). The National Energy Regulator (NERSA) has released draft rules for Small-Scale Embedded Generation (SSEG), to regulate tariffs to promote SSEG of between 100 kW and 1MW. NERSA has approved municipal SSEG tariffs on a case-by-case basis, but given the rapid change towards smart grids and distributed generation globally, as well as the implications for municipal revenues when customers become suppliers, urgent attention is needed. Local government is reporting increased SSEG across municipalities (SALGA, 2017). The patterns of investment and distributional implications differ markedly between the historical centralised model (big power and big networks) and decentralised systems (Baker *et al.*, 2015).

6.3.8 Waste

Some aspects of waste management have an impact on the climate, for instance, through the generation of methane. The waste sector is organised in the National Recycling Forum and Institute of Waste Management in South Africa. The DST has developed the Waste Research, Development and Innovation Roadmap to coordinate and manage investments with all stakeholders. This initiative started in 2015 and the 2016/2017 Annual Report indicates that the investment in waste research, development and innovation (RDI) is around R1.9 million for the private waste sector during that period. In 2017, Mintek finalised a study for the DST regarding the technology landscape in the e-waste sector. It concluded that off-the shelf technologies are readily available from outside South Africa, but that costs and skills are barriers to implementation (Appendix 6).

7 UPDATE ON THE LEGISLATIVE AND POLICY ENVIRONMENT

The first biennial climate change S&T report included an extensive review of the relevant legislative and regulatory environment, as requested in the terms of reference. This second biennial report updates that survey (Appendix 7). In this section, only the relevant changes are noted.

In the 2012 – 2018 period, six White Papers of relevance to the issue of climate change were published: in 2012, the Gauteng Innovation and Knowledge Economy Strategy; in 2016 the Protection, Promotion, Development and Management of Indigenous Knowledge Bill; in 2017 the National Carbon Tax Bill (second draft) and the National Research Foundation Amendment Bill; and in 2018, the Aquaculture Development Bill, Ikamva National E-Skills Institute Bill, and the National Climate Change Bill. No relevant Acts were passed in this period.

In the period 2012 – 2018, the following provincial and metropolitan climate-relevant strategies and frameworks were introduced: 2012 – Gauteng Innovation and Knowledge Economy Strategy; 2014 – Western Cape Climate Response Strategy, Eastern Cape Provincial Development Plan, Buffalo City Metropolitan Municipality Climate Change Strategy, Limpopo Provincial Development Plan; 2015 – North West Province Department of Rural, Environment and Agricultural Development 2015 – 2020 Strategic Plan; 2016 – Mpumalanga Climate Adaptation Strategy Report, Msunduzi Municipality Climate Change Adaptation and Mitigation Strategy, City of Mbombela Climate Change Response Strategy and Implementation Plan, KwaZulu-Natal Growth and Development Strategy, Limpopo Provincial Climate Change Response Strategy 2016 – 2020; and 2017 – City of Johannesburg Air Quality Management Plan.

The NPC is considering climate change and the transition to a low-carbon economy in its process leading to the 2nd National Development Plan. NPC Commissioners Jarrad Wright and Tasneem Essop, published a paper on Energy in 2018. The Pathways to a Just Transition in South Africa project is currently midway through its three-year timeframe (2017 – 2019).

The South African Marine Research and Exploration Forum (SAMREF) has been launched through Operation Phakisa. Oceanographic and geological research opportunities provided by offshore oil and gas exploration activities are specified as objectives of the ocean's economy.

The National Climate Change Bill was published for public comment in June 2018. The Bill makes provision for national contributions to the stabilisation of global GHG concentrations in the atmosphere, and thus setting the national GHG emissions trajectory. The Bill focuses on mechanisms of policy coordination, such as the establishment of an interministerial committee on climate change, towards the development of a cooperative, integrated response to climate change. It places responsibilities on national government departments, SoEs, provinces, and municipalities to evaluate their climate change response needs, formulate response strategies and undertake their implementation. It calls for the formation of a National Adaptation Strategy, detailing vulnerability and risk. In its second draft form, the Bill does not prioritise climate change, National Treasury published the National Carbon Tax Bill for public comment in 2017, following its approval by Cabinet. The Bill provides for the imposition of a tax on the carbon dioxide-equivalent of GHG emissions. The Bill encompasses a variety of associated

measures, including carbon pricing, tax incentives for voluntary actions; and the use of offsets to reduce carbon-based taxation. Conversion of this Bill into an Act would increase the motivation for the development and adoption of emission-reduction technologies.

The 2017 Bill to amend the 1998 NRF Act states the definition of technology as “the manner through which knowledge accumulated through research or observation finds practical application”.

Several of the provincial and metropolitan climate strategies implement vulnerability and risk assessment. Most mention the need for more information, and provincial or local research and technology adaptation activities. Some provinces have an explicit innovation strategy (e.g. the Gauteng Innovation and Knowledge Economy Strategy (2012)) while others mention the need in their general growth and development strategies.

The South African Local Government Association (SALGA) has formed a working group on environmental planning and climate resilience. SALGA also has a working group focused on municipal innovations and information technology which is concerned with supporting municipalities in dealing with information and communications technology (ICT), knowledge sharing, and disruptive technologies and systems. The SALGA Electricity and Energy Provision National Working Group focuses on energy-related matters.

8 CONCLUSION

The second biennial report on the *State of Climate Science and Technology in South Africa* covers the period 2016 – 2017. It aimed to, not only, update information provided in the first biennial report which covered the period 2005 – 2015, but also to address some of the gaps identified in the first report. Chief among these, were to gain a better understanding of technology development related to climate change (i.e. the bringing of research to market or application in the form of prototypes and pilot projects) and investments by the private sector.

8.1 Summary of major findings

Research publications

Nearly 40% of all global research publications relevant to climate change in southern Africa and its surrounding oceans for the period 2016 – 2017 were attributed to South African institutions. The largest contribution in SA comes from universities (85%), followed by government-associated research institutions and agencies (12%). The pattern of dominance by five leading universities (UCT, UKZN, SU, UP and Wits) continued; together they are responsible for 56% of the published output. Each contributes nearly 10%; the next nine universities, which include several formerly disadvantaged institutions, contribute 1% to 4% each, about the same order-of-magnitude as each of the five research councils and government-linked agencies active in this field.

The climate change field is by its nature highly globalised. South African researchers and research institutions have strong interactions with their counterparts in many parts of the world. The biggest obvious shortfall is in relation to Africa. The overall publication rate on climate change in Africa excluding South Africa is low – 8% of the global total.

Production of postgraduate researchers

In the period 2016 – 2017, a total of 120 Masters degrees and 104 doctoral degrees were awarded by SA HEIs in fields related to climate change research. The number of high-level graduates per year (112) is apparently five-fold higher than the 22 per year generated over the period 2005 – 2015, but this is thought to merely reflect the improved quality of the databases used in the more recent analysis. A slightly different mix of universities leads in the production of Masters and doctoral graduates in this field, with the University of Cape Town (UCT) and University of Pretoria (UP) dominating over this period.

Investments in climate change S&T

In an attempt to fill the gaps in the first biennial report, two studies were commissioned to survey sources and levels of investment accessed through climate change international finance instruments and from the private sector. The first biennial report suggested that national investment in climate-related S&T was in the order of R400 million per year. The more comprehensive funding-source evaluation indicates that the annual value is closer to R900 million per year. Much of the difference relates to funds mobilised by the private sector (including SoEs) and support from international financial instruments; and it is largely spent on technology development in the climate mitigation space.

Of the 37 international instruments identified as available to fund investments in S&T for mitigation and adaptation to climate change, SA managed to access funding from only 16. Based on a detailed analysis of six international climate finance instruments, SA used more than one-third (36.9%) of all the funds approved for the entire SSA. To date, SA is the only country in SSA to access funds available through the PMR instrument, which supports the development of national programmes for enabling the use of market mechanisms to facilitate adoption and spread of climate mitigation innovations. This reflects the relative progress made in SA towards implementing market-based policy instruments for promoting low-carbon growth, compared with the rest of the continent. There is, however, a large potential for more external funding through other global finance instruments that are not yet utilised.

Climate S&T in the private sector

Private sector investment into climate change activities has largely focused on mitigation, for which it is easier to establish a return on investment, than is the case for climate adaptation. The return can result either through the generation and sale of renewable energy, or through energy savings from increased efficiency.

Funded projects in the private sector including organic waste treatment to energy and energy efficiency projects. The newly-established Climate Finance Facility in the Green Fund is not yet operational. It will use its capital to fill market gaps and crowd in private investment, targeting commercially viable technologies that cannot currently attract market-rate capital at scale and will focus on infrastructure projects that mitigate or adapt to climate change (DEA, 2016a). The TIA funds the CICSA. CICSA supports 34 companies in an early stage of development and which focus on the energy, waste and water sectors (Innovation Hub, 2018).

Government has developed a number of incentives to promote climate mitigation activities in the private sector. These include tax incentives for companies implementing energy efficiency and CDM projects; an accelerated depreciation allowance for investments in renewable energy and biofuels production; a levy on incandescent lightbulbs to incentivise the switch to more energy-efficient options; a tax on carbon emissions by vehicles to incentivise the switch to fuel-efficient vehicles; a levy on electricity consumption from non-renewable sources, and the long-awaited carbon tax and associated carbon offsetting regime.

There are few examples of climate-smart technology development by the private sector in SA; the practice has largely been to implement or resell existing technologies. However, there are some investments into research on new energy-related products, for example, research on clean coal technologies; research on PGMs since platinum is an excellent catalyst in fuel cells and would contribute towards the development of a local fuel cells manufacturing industry; and research on innovative energy storage mechanisms.

8.2 Recommendations

The second biennial report on climate change S&T makes the following recommendations:

- Help to raise the overall climate change analytical capacity in Africa by fostering collaboration among research institutions in Africa, particularly between SA and other African countries.
- Continue to monitor and evaluate the effectiveness of SA engagement in climate change-related S&T on a regular basis, building on the baseline established by the first and second biennial reports, and introducing metrics which enable the effectiveness of research to be tracked.

- Build on successes in accessing international funding instruments for the support of climate change S&T by preparing project proposals for the several opportunities which are available to SA, but not yet used.
- Make maximum use of the apparently high demand for 'green' funding instruments in the private sector.
- Encourage private sector programmes to replace fossil fuel-based energy sources at enterprise level with renewable energy, and include this strategy in ongoing energy sector planning. To date, only a very small fraction of identified opportunities to do so has been realised.
- SA should strategically position itself as a world leader in relation to one or a few emerging low-carbon energy technologies. An example is CSP, a technology well suited to SA conditions and skills, with the advantage of built-in storage, and where the market does not yet have a clear leader. Other potential areas could include manufacture of components for renewable energy technologies, and fuel cells, particularly where they require PGMs.
- Government should create an enabling environment for small-scale embedded generation and energy efficiency incentives. Urgent attention to this domain is needed, given the rapid change towards smart grids and distributed generation globally, as well as the implications for municipal revenues when customers become suppliers.
- The SA investment in climate-related technologies would be more effective if it were better-coordinated across the many individual domains in which it occurs: the energy, water, infrastructure, agriculture and biodiversity sectors, for instance. In some domains there are potentially contradictory or counterproductive initiatives which should be rationalised.
- SA should learn from, and build on, the highly effective role that the IPP office played in accelerating the deployment of renewable energy. The approach can continue to be effective in that domain and for energy technologies more generally.
- A just transition to low-carbon and climate-resilient economy and society is a priority. The announcement of a Presidential Climate Change Coordinating Commission to coordinate and oversee the just transition is an important step.
- South Africa is well positioned, by virtue of its S&T capacity in adaptation, to play a key role in the Global Commission on Adaptation, launched in October 2018 in The Hague to advance climate change adaptation solutions.

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APPENDICES

Appendix 1: Panel members and biographies.....	55
Appendix 2: Procedure for survey of journal and book publications.....	57
Appendix 3: List of people and institutions consulted.....	63
Appendix 4: Assessment of South Africa's leveraging of international funding instruments for climate change-related research and technology development	65
Appendix 5: Investigation into activities and investments by the private sector of South Africa	104
Appendix 6: Details of the data sources supporting funding analyses	117
Appendix 7: Update of the review of legislation and policy instruments for climate change research and technology in South Africa.....	125

APPENDIX 1: PANEL MEMBERS AND BIOGRAPHIES

RJ (Bob) Scholes

Prof Bob Scholes is Distinguished Professor of Systems Ecology in the Global Change Institute, Wits. He has worked on issues associated with Global Change, including climate change, since 1990, and is widely published and cited on this and other topics. He has participated in or led several high-profile climate-related studies (e.g. Beddington Commission on Sustainable Agriculture and Climate Change, Strategic Assessment of Shale Gas Development, Southern African Millennium Assessment, IPBES Land Degradation and Restoration Assessment) and large research campaigns (e.g. SAFARI 2000). He was an author of the IPCC 3rd, 4th and 5th assessments. He has been on the boards of the International Centre for Research in Agroforestry, the South African National Parks and South African National Space Agency. He is a Foreign Associate of the US National Academy of Sciences, Fellow of The World Academy of Sciences (TWAS), Fellow of the Royal Society of South Africa, Member of ASSAf, an NRF A-rated scientist, and a winner of the National Science and Technology Forum Lifetime Contribution to Science Award.

Roseanne Diab

Prof Roseanne Diab is the former Executive Officer of ASSAf and Emeritus Professor in Environmental Sciences at UKZN. She is a Fellow of the university, the South African Geographical Society, TWAS, the African Academy of Sciences (AAS) and a Member of ASSAf. Her research interests are in atmospheric science, with a focus on climate change and air quality. She has over 100 publications in peer-reviewed journals and has supervised approximately 50 PhD and Masters students. Diab has served on numerous international committees such as the International Ozone Commission (IOC), the Commission on Atmospheric Chemistry and Global Pollution (CACGP) and the SPARC (Stratospheric Processes and their Role in Climate) Steering Group. She is active in the Organisation for Women Scientists in the Developing World (OWSD), has served as co-chair of the Gender Advisory Board to TWAS and is currently a special advisor to Gender in Science, Innovation, Technology and Engineering (GenderInSITE).

Rashid Hassan

Prof Rashid Hassan is currently Emeritus Professor at UP. He served as Professor and the founding Director of the Centre for Environmental Economics and Policy in Africa until 2016 and previously worked at the CSIR, Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) International in East Africa, and the University of Juba in Sudan. He served as member of many national and international boards and science councils including: the UN Committee for Development Policy at UN Economic and Social Council (ECOSOC), the Consultative Group on International Agricultural Research (CGIAR), the Independent Science and Partnership Council (ISPC), Global Environment Fund (GEF) Science and Technical Advisory Panel, Science Panel and Co-Chair of the Condition and Trends Working Group of the Millennium Ecosystem Assessment, High-Level Panel of Experts on Food Security and Climate Change of the UN Committee on World Food Security, Academic Advisory Panel for the World Development Report on climate change, Stockholm Resilience Centre Board,

Stockholm Environment Institute Science Advisory Council, and the board of the HSRC. His main research expertise covers broadly the economics and policy of agriculture, natural resources and environmental management with current special interest in environmental accounting, climate change economics and sustainable management of natural ecosystems, particularly the economics and policy of governing the commons.

Danny Simatele

Prof Danny Simatele of an Associate Professor in the School of Geography, Archaeology and Environmental Studies, Wits. Before joining Wits, he worked for the following universities: University of St Andrews in Scotland, University of Manchester – UK, University of Brighton – UK, University of Sussex – UK, The Open University in the South at Oxford and the University of Gothenburg in Sweden. His research interests straddle human processes, the built environment and the physical environment. His research focus has revolved within the following broad areas:

- Climate change adaptation in urban areas of the developing South
- Urban and peri-urban transformations
- Rural and urban agriculture
- Environment and migration
- Community-based development and institution building in sub-Saharan Africa
- Sustainable development.

Harald Winkler

Prof Harald Winkler is Professor at the Energy Research Centre at UCT. His research interests are focused around energy and climate policy, at international and national level. Current focus areas include: climate change mitigation, poverty and inequality; economic analysis of mitigation; the future of the climate regime and implementation of the Paris Agreement, including transparency; equity in nationally determined contributions and 'zero poverty zero emissions' development pathways, and comparative analysis of mitigation actions in cities and in developing countries. His approach is transdisciplinary, co-producing knowledge with stakeholders to make a difference in a just transition to a low-carbon, job-rich world. This builds on earlier research, including that underpinning South Africa's Long-Term Mitigation Scenarios (LTMS). From 2010 to 2015, a significant focus of his work with other developing countries to share the LTMS experience in a programme called MAPS – Mitigation Action Plans and Scenarios (see www.mapsprogramme.org). Winkler is rated as an "internationally acclaimed researcher" by SA's NRF, is a member of editorial boards of five international journals, joint Editor-in-Chief of *Climate Policy* and won the National Science and Technology Forum (NSTF) 2017/18 special annual theme award Sustainable Energy for All. He has been a member of the South African delegation to the negotiations under the UN Framework Convention on Climate Change and a (coordinating) lead author for the Intergovernmental Panel on Climate Change's Working Group III on mitigation for the 4th, 5th and 6th assessment reports.

APPENDIX 2: PROCEDURE FOR SURVEY OF JOURNAL AND BOOK PUBLICATIONS

The following procedure was undertaken in order to conduct a bibliometric survey of climate change research in 2016 and 2017:

- 1 The WoS was used as the database from which to extract publications. The WoS was selected as it has expansive functionality, a rich underlying database, includes the 'gold standard' outputs, and can export to Excel for processing of data and graphical representation.
- 2 Publications were extracted on a year-by-year basis (publication year) for both years.
- 3 Keywords used in the search are listed below. Search terms included overarching topics such as 'climate change', 'global change', 'climate adaptation', 'climate mitigation', 'climate impacts', 'climate system' and a long list of sector and sub-discipline-based search terms. The list of search terms was derived by the panel based on the search terms used in the Norwegian Report on climate change research. These were adapted to suit the South African context. All search terms used in the survey are listed below.
- 4 The author address was used to filter the potential results to include only those with at least one author based in South Africa.
- 5 Only journal articles and chapters in books were included in the survey as these are peer-reviewed, substantive publications.
- 6 Using the results yielded from WoS, data were analysed by producing a graph of publication units, per year for the period 2016 – 2017, and determining the trend line for productivity.
- 7 Outputs were also sorted by institution, to establish which are the most productive institutions overall, and to evaluate whether this ranking had changed between 2006 – 2010 vs 2011– 2015.
- 8 Rates for the distribution of citations were evaluated to determine whether the overall (mean) citation rate for South African-authored papers is higher or lower than the average for these journals for all authors. Furthermore, the rates for distribution were assessed to determine to what degree the citation rate is concentrated in a few top-end papers.

Co-authorships were examined to determine which countries/institutions South African researchers collaborate with and to establish which South Africa institutions work together on climate-change research.

South African topic search terms

Climate system

Biosphere

biosphere climat*
biome* climat*
forests climat*
forest climat*
biodiversity climat*
coral reef* climat*
ecosystem* climat*
biological species* climat*
phenolog*
biological system* climat*
climat* AND (plankton* OR phytoplankton
OR zooplankton)
vegetation climat*

Hydrosphere

hydrosphere climat*
river* climat*
wetland* climat*
catchment climat*
ocean* climat*
seas* climat*
aquifer AND climat*
sea level climat*
sea level AND (change* OR rise)
ocean acidification
"tide gauge*" AND climat*
(streamflow OR river discharge) AND climat*
"saltwater intrusion" AND "sea-level ris*"
arid region* AND climat*
desert* AND climat*
drought AND climat*
flooding AND climat*
erosion AND climat*
groundwater AND climat*
hydrographic events AND climat*
isohyet AND climat*
landslide* AND climat*
"saltwater intrusion" AND climat*
runoff AND climat*
semi-arid region* AND climat*
streamflow AND climat*
storm surge AND climat*
upwelling region AND climat*
cryosphere climat*
Antarctica AND climat*
Southern Ocean AND climat*
Sub-Antarctic island* and climat*
"Ice cap" AND climat*

"sea ice" AND climat*
(ice shelf*) AND climat*

Atmosphere

atmospher* AND climat*
cloud* climat*
meteorological drought*
(Extreme weather event*) AND climat*
monsoon* AND climat*
"radiative forcing" AND climat*
weather AND climat*
(storm* OR cyclon*) AND climat*
tropospher* AND climat*
stratospher* AND climat*
tropopause AND climat*
meteorolog* AND climat*

Land surface temperature

land surface* AND climat*
borehole temperature* climat*
surface temperature* climat*
"soil temperature" climat*
global surface temperature

Biota

benthic communit* AND climat*
biota AND climat*
coccolithophores AND climat*
Coral* AND climat* NOT Reef*
ecological communit* AND climat*
ecological corridor* AND climat*
ecophysiological process* AND climat*
ecotone AND climat*
food chain* AND climat*
extinction AND climat*
extirpation AND climat*
habitat AND climat*
"keystone species" AND climat*
limnolog* AND climat*
(peat OR peatland) AND climat*
pelagic communit* AND climat*
(phytoplankton OR plankton) AND climat*
("population system" OR "ecological system*") AND climat*
pteropods AND climat*
succulent* AND climat*
savann* AND climat*
karoo AND climat*
grassland AND climat*
rangeland AND climat*
shrubland AND climat*
fynbos AND climat*
trophic AND climat*

Carbon sequestration

Sout* Africa AND climate
topograph* AND climate
land-use AND climate
carbon sequestration

Climate system patterns

"climate system"
"climate feedback*"
Climate-carbon cycle coupling
"Climate sensitivity"
"Climate shift" OR "climate regime*" OR (Patterns of climate variability)
"El Nino-Southern Oscillation"
Climat* variability
erosion climat*
Evapotranspiration OR "water evaporation" OR transpiration
"Southern Annular Mode" OR "Antarctic Oscillation"
albedo NOT Subject Areas=(ASTRONOMY & ASTROPHYSICS)
albedo feedback*
"solar activity" AND climat*
"energy balance" AND climate
climat* history
palaeoclimat*
paleoclimat*
interglacial*
last glacial maximum
dendroclimatolog*
climat* AND (precambrian* OR phanerozoic*OR quaternary* OR proterozoic* OR holo-
cene* OR "hockey stick*" OR "temperature record*" OR "lithologic indicators" OR "Dans-
gaard-Oeschger*" OR
"pollen analys*" OR pleistocene OR "warm period*" OR "tree ring")
"ice core*" OR "ice-core*" OR "icecore*"
Climate change*
Abrupt climate change*
Rapid climate change*
thermohaline circulation
soil respiration
carbon cycle
aerosol* climate
aerosol* AND cloud*
algal bloom
desertification
coral bleaching
deforestation climate
land-use change climate
forestry climate
plantation climate
human-induced degradation of forest*
impact* AND ("climate change*" OR "climate shift*" OR "climate variab*")
aggregate impacts AND "climate change*"
impact assessment AND ("climate change*" OR "climate shift*")
integrated assessment AND ("climate change*" OR "climate shift*")
market impact* AND climate change

market potential* AND climate change
net market benefit* AND climate change

Adaptation

resilience AND climat*
Vulnerability AND "climate change"
acclimatisation AND "climate change*"
climate change* adaptation*
climate change* adaptive capacit*
adaptability AND climate change*

Coasts

mangrove* AND climate change*
mud AND sand flats AND climate change*
Diseases
disease* AND climate change*
"dengue fever" AND climate change*
cholera AND climate change*
virus AND climate change*
hantavirus AND climate change*
malaria AND climate change*
meningitis AND climate change*
morbidity AND climate change*
zoonoses AND climate change*

Global warming

("carbon dioxide" OR CO2) AND fertilisation
("food security" OR "food insecurity") AND climat*
"global warming"
"greenhouse effect*"
Emissions
Anthropogenic emission*
greenhouse gas*
Carbon dioxide emission*
Carbon dioxide equivalent*
CO2 equivalent*
CO2 emission*
methane emission*
nitrous oxide emission*
hydrofluorocarbon* emission*
perfluorocarbon* emission*
sulphur hexafluoride* emission*
CH4 emission*
N2O emission*
PFCs emission*
SF6 emission*
"carbon leakage"
"carbon intensity"
climate threshold

Climate models

Climate model*
Coupled Atmosphere-Ocean General Circulation Model*

GCM
AOGCM*
climate prediction*
climate forecast*
climate projection*
climate scenario*
emission* scenario*
SRES scenario*
RCP
“dynamic global vegetation model” OR DVGM

Mitigation

Mitigation climate change
United Nations Framework Convention on Climate Change OR UNFCCC
Joint Implementation climat*
Kyoto Mechanism*
Kyoto Protocol*
Clean Development Mechanism* OR CDM
Certified Emission Reduction Unit* climat*
mitigation climate change
mitigation climate change potential*
mitigation climate change capacit*
mitigative climate change capacit*

Economic policy measures

emission* trading
tradable permit*
Taxes AND climat*
carbon tax*
energy tax*
eco tax*

Policy

climate policy
climate politic*
energy policy
(technology transfer OR “technological change”) AND climate
voluntary AND (action* OR agreement*) AND climate
afforestation
reforestation
“renewable energy”
(fuel cell*) OR hydrogen
methane recovery
retrofitting AND climat*
biofuel* AND climate

APPENDIX 3: LIST OF PEOPLE AND INSTITUTIONS CONSULTED

Name	Affiliation
Neville Sweijd	ACCESS
Mokhele Moeletsi	ARC
Sewela Malaka	ARC
Phumzile Maluleke	ARC
Thomas Fyfield	ARC
Emmanuel Mwendera	ARC
Malebo Maleka	ARC
Mphekgo Maila	ARC
Shadrack Moephuli	ARC
Petronella Chaminuka	ARC
Hendrik Louw	Consultant
Kent Buchanan	DEA
Dineo Ngobeni	DEA
Peter lukey	DEA
Jongikhaya Witi	DEA
Nhlanhla Sithole	DEA
Azwimpheleli Mac Makwarela	DEA
Thabang Audat	DoE
Mokgadi Modise	DoE
Leluma Matooane	DST
Henry Roman	DST
Yonah Seleti	DST
Smangele Mgquba	DWA
Shingirirai Mutanga	HSRC
Dave Collins	MAC Consulting
Jonathan Diederiks	NRF
Prudence Makhura	NRF
Peter Shisani	NRF/SASSCAL
Johan Pauw	SAEON
Wim Hugo	SAEON
Beate Hölscher	SAEON
Caradee Wright	SAMRC
Karen Surridge	SANEDI
Andiswa Mlisa	SANSA

Hannes Rautenbach	SAWS
Johan van den Berg	Skrander
Petro de Wet	TIA
Thabiso Letsebe	TIA
Gina Ziervogel	UCT
Mark New	UCT
Philani Moyo	UFH
Kingsley Ayisi	UL
Catherine Sutherland	UKZN
Brilliant Petja	WRC
Hlekani Kabiti	WSU

APPENDIX 4: ASSESSMENT OF SOUTH AFRICA'S LEVERAGING OF INTERNATIONAL FUNDING INSTRUMENTS FOR CLIMATE CHANGE-RELATED RESEARCH AND TECHNOLOGY DEVELOPMENT

1 Introduction

The details and magnitude of SA's national investment into climate change R&TD were investigated as part of the first biennial report completed in December 2016 (ASSAf, 2016). However, to what extent SA researchers and organisations leverage international funding instruments was not adequately covered. This investigation seeks to understand the role that international funding instruments are playing in the SA climate change research and technology landscape and to identify major funding opportunities that are currently not being exploited and which could be of benefit to SA.

Specifically this research aims to do the following:

- 1 Identify international climate change funding instruments (ICCFIs) available to SA and briefly describe their focus, applicability and terms and conditions.
- 2 Identify which of the ICCFIs have been utilised by SA, and where possible, give an account of the levels of funding, individuals and organisations involved, the focus of the research or activity, and assess the benefit to SA R&TD.
- 3 Identify ICCFIs that are currently not utilised by SA, but may be of significant benefit to the country's performance in terms of climate R&TD. Identify any obstacles which may have led to the under-utilisation.

2 Sourcing and organisation of the collected data

A desktop research approach was used for the purposes of this study. The data utilised for the study was collected through a systematic literature search on bibliographic databases (i.e. ScienceDirect, Scopus, WoS and Google Scholar) and the Internet in general (i.e. a normal Google search). The literature search covered journal articles, policy briefs, research reports and grey literature. All documents were screened to check if they contained the relevant information required for the purposes of this study. The retained documents were then reviewed to identify and extract information on the various typologies of available ICCFIs. Websites for all instruments were utilised to gain detailed information (such as the description, terms and conditions and funding stakeholders) on each of the identified instruments. The Climate Finance Update data was also utilised to obtain information on the major ICCFIs, including amount of funding approved, focus areas of the instruments and the projects being funded under each instrument.

A three-pronged analytical framework was used to conduct the intended study. Qualitative document, content, and narrative analyses were applied to review, interpret, synthesise, and extract the required information. The results of the aforementioned analytical framework are presented in tabulated matrices in the form of a custom-built Microsoft Excel

spreadsheet database. The developed database consists of seven sheets namely; (i) List of International Finance Instruments (Table 4-1), (ii) Instrument terms and conditions (Table 4-2), (iii) Climate funds approved for SSA projects for the period 2003 – 2017 (Table 4-3), (iv) Climate funds approved for projects in SA for the same period (Table 4-4), (v) SSA country profile containing Climate funds approved per country (Table 4-5), (vi) Utilised international financial instruments in SA (Table 4-6), and (vii) Non-utilised international financial instruments in SA (Table 4-7). The tables are provided at the end of this report.

3 Findings and description of the custom-built database

A total of 37 major ICCFIs were identified, most of which are multilateral. Focus of the identified ICCFIs covered five main areas, namely: (i) Climate change adaptation, (ii) Climate change mitigation, (iii) Reduction of emissions from deforestation and forest degradation (REDD+), (iv) REDD+, and (v) multiple foci (i.e. focusing on many issues). Table 4-1 lists all ICCFIs together with the financing typology and focus. The table also gives a brief description and the status of utilisation of each funding instrument by SA. The website where more detailed information about each funding instrument is also provided in the table.

The terms and conditions of all the identified major ICCFIs are presented in Table 4-2 tabulated matrix with two columns.

3.1 The share of SA in climate funds approved for SSA projects (2003-2017)

Levels of funding approved for SSA under each instrument is presented in Table 4-3. Only 18 of the 37 instruments identified had information on the levels of funding for the 2003 to 2017 period. Table 4-4 presents the information regarding levels of climate funds approved for SA and lists projects funded under six of the 37 ICCFIs identified, namely: The Global Environmental Facility (GEF), The Adaptation Fund (AF), Green Climate Fund (GCF), Partnership for Market Readiness (PMR), Special Climate Change Fund (SCCF), and the Clean Technology Fund (CTF). As for the other international instruments identified, there was either no information available for the period 2003 – 2017 or non-tracking of finance approved for SA projects.

Levels of funding approved during the 2003 to 2017 period for the entire SSA region are given, per country, in Table 4-5. Funds updates showed that approximately US\$ 3.6 billion had been approved to fund a total of 506 projects and programmes in the entire SSA region. More than 50% of the aforementioned funds supported climate change adaptation measures. The search results also indicate that SA has been the major beneficiary of all climate funding directed at the SSA region with a share about 17% (US\$ 590 million) of all funding approved under all the major international multilateral funding instruments since 2003 (Table 4-5). The majority of this funding was channelled mostly to support Eskom’s renewable energy programme under CTF.

3.2 Utilisation of ICCFIs by South Africa

Table 4-6 provides details on ICCFIs available for SA, including the funding typology and focus, status of utilisation by SA, and names of identified research projects that have been funded (or are funded) under each instrument. The results show that 16 or 18 of the 37 ICCFIs identified, have been (or are) utilised by SA. ICCFIs available, but not utilised yet by SA, are given in Table 4-7, which also presents possible obstacles and reasons for non-utilisation.

The results suggest that the major reasons/obstacles for non-utilisation were largely attributed to the lack of policy alignment, complex governance procedures, lack of skilled technical capacity and human resources and resistance to change (e.g. over-reliance on fossil fuel-based energy instead of proactive actions in the adoption of RE) in government to mention a few.

Table 4 - 1: List of international finance instruments

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
1	Global Environmental Facility (GEF)	Multilateral	Adaptation	The GEF is an operating entity of the financial mechanism for the United Nations Framework Convention on Climate Change (UNFCCC) which is involved in financially supporting developing countries' projects in relation to mitigation and adaptation.	Utilised	https://www.thegef.org/
2	The Adaptation Fund	Multilateral	Adaptation	The Adaptation Fund is a multilateral sources of funding that was created in 2009 under the UNFCCC and the Kyoto Protocol to support climate change adaptation projects for countries in the developing world.	Utilised	https://www.adaptation-fund.org/
3	The Group on Earth observations (GEO)	Multilateral	Multiple foci	The GEO is a voluntary partnership of 102 member states, the EU and a further 103 organisations that have a focus on earth systems observations with the aim of establishing and maintaining a comprehensive repository of Earth observation data and information for future use in global decision making processes.	Utilised	https://earthobservations.org/index2.php
4	Future Earth	Multilateral	Multiple foci	Future Earth is a multilateral initiative that was established to advance global sustainability science by building capacity and providing an international agenda that can guide research in this arena.	Utilised	http://www.futureearth.org/

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
5	The Belmont Forum	Multilateral	Multiple foci	The forum serves to group many of the major funders of all aspects of global environmental change research with the aim of accelerating research that is required to tackle critical issues pertaining to global sustainability through the use of interdisciplinary and transdisciplinary research.	Utilised	http://www.belmontforum.org/
6	Climate Technology Centre and Network	Multilateral	Multiple foci	The CTNC is mechanism for supporting climate change related technology development and transfer, particularly for the purposes of fostering clean and more efficient energy supply, the reduction of carbon emissions, climate resilience development and additional mitigation efforts serving specific sectors.	Utilised	https://www.ctc-n.org/
7	Green Climate Fund	Multilateral	Multiple foci	Formerly named the Copenhagen Green Fund after the Copenhagen Accord in 2009, the GCF was adopted at COP 17 in December 2012 as an initiative to drive and support projects related to lowering emissions and fostering development that is climate resilient.	Utilised	https://www.greenclimate.fund/home
8	Global Green Growth Institute (GGGI)	Multilateral	Multiple foci	The GGGI was initiated in 2012 as a result of the Rio +20 UN Conference on Sustainable Development with the aim to integrate economic growth, social inclusion, environmental sustainability and poverty alleviation in poorer and emerging economies.	Utilised	http://www.greengrowthknowledge.org/organization/global-green-growth-institute-gggi

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
9	Climate and Development Knowledge Network (CDKN)	Multilateral	Multiple foci	The CDKN is a network of actors which support the adoption of development which is climate responsive in partnership with various relevant stakeholders to inform, support and partake in the planning and research design and implementation of climate development.	Utilised	https://cdkn.org/?loclang=en_gb
10	International Institute for Applied Systems Analysis (IIASA)	Multilateral	Multiple foci	The IIASA is an international scientific institute that conducts research into the critical issues of global environmental, economic, technological, and social change that we face in the twenty-first century.	Utilised	http://www.iiasa.ac.at/
11	Partnership for Market Readiness (PMR)	Multilateral	Mitigation	The PMR provides a platform for sharing experience, fostering new and innovative market-based instruments, and building market readiness capacity for countries to scale up climate change mitigation efforts.	Utilised	https://www.thepmr.org/
12	Carbon Fund	Multilateral	Mitigation	The CF is one of the two trust funds of the CPF that serves the purpose of purchasing carbon credits from the pool of emission reduction programmes.	Not utilised	https://carbonfund.org/
13	Carbon Assessment Development Fund (CADF)	Multilateral	Mitigation	The CADF is also one of the two trust funds of the Carbon Partnership Facility (CPF) that prepares and implements emission-reduction programmes.	Not utilised	https://cpf.wbcarbonfinance.org/content/what-cpf

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
14	Forest Carbon Partnership Facility Readiness Fund (FCPF)	Multilateral	REDD+	The Forest Carbon Partnership Facility is a global partnership of governments, businesses, civil society, and Indigenous Peoples focused on reducing emissions from deforestation and forest degradation, forest carbon stock conservation, the sustainable management of forests, and the enhancement of forest carbon stocks in developing countries (activities commonly referred to as REDD+). The Readiness Fund supports participating countries in the development of REDD+ strategies and policies, reference emission levels, measurement, reporting, and verification systems, and institutional capacity to manage REDD+, including environmental and social safeguards.	Not utilised	https://www.forestcarbonpartnership.org/readiness-fund-0
15	Carbon Initiative for Development (Ci-Dev) Readiness Fund	Multilateral	Multiple foci	The Carbon Initiative for Development (Ci-Dev) was launched in December 2011 to build capacity and develop tools and methodologies to help the world's poorest countries access carbon finance, mainly in the area of energy access. It is set up to use performance payments based on reduced emissions to support projects that use clean and efficient technologies in low-income countries.	Not utilised	https://www.ci-dev.org/about-us

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
16	BioCarbon Fund Initiative for Sustainable Forest Landscapes (BioCF ISFL)	Multilateral	REDD+	The BioCarbon Fund Initiative for Sustainable Forest Landscapes collaborates with forest countries around the world to reduce emissions from the land sector through smarter land use planning, policies, and practices. It promotes reducing greenhouse gas emissions from the land sector, from deforestation and forest degradation in developing countries (REDD+), and from sustainable agriculture, as well as smarter land-use planning, policies and practices.	Not utilised	https://www.biocarbonfund-isfl.org/
17	Pilot Programme for Climate Resilience (PPCR) I/II	Multilateral	Adaptation	Pilot Programme for Climate Resilience (PPCR) supports developing countries and regions in building their adaptation and resilience to the impacts of climate change.	Not utilised	https://www.climateinvestment-funds.org/topics/climate-resilience
18	Ozone Trust Fund (OTF) (i.e. Montreal Protocol)	Multilateral	Mitigation	Adopted in 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer legally enforces the phase-out of the production and use of ozone depleting substances – chemicals often used in refrigeration, air-conditioning, foam manufacturing, aerosol production, and fire extinguishing.	Utilised	http://www.worldbank.org/en/topic/climatechange/brief/montreal-protocol
19	Least Developed Countries Fund (LDCF)	Multilateral	Adaptation	The fund, managed by the GEF, supports the world's most vulnerable countries in their efforts to adapt to the effects of climate change.	Not utilised	https://www.thegef.org/topics/least-developed-countries-fund-ldcf

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
20	Special Climate Change Fund (SCCF)	Multilateral	Adaptation	The Special Climate Change Fund (SCCF) was established in response to guidance from the Conference of the Parties (COP7) in Marrakech in 2001. The SCCF complements the Least Developed Countries Fund (LDCF). Unlike the LDCF, the SCCF is open to all vulnerable developing countries.	Utilised	https://www.thegef.org/topics/special-climate-change-fund-sccf
21	Global Fund for Disaster Reduction and Recovery (GFDRR)	Multilateral	Adaptation	The Global Facility for Disaster Reduction and Recovery (GFDRR) is a global partnership that helps developing countries better understand and reduce their vulnerability to natural hazards and climate change.	Utilised	https://www.gfdr.org/en/learning-from-megadisasters-knowledge-note-2-5
22	Korea Green Growth Trust Fund (KGGTF)	Multilateral	Multiple foci	The Korea Green Growth Trust Fund (KGGTF) is a partnership between the World Bank Group (WBG) and the Republic of Korea. As an implementation-focused trust fund that prioritises the World Bank's inclusive green growth objectives, this partnership supports countries in their sustainable growth strategies and investments.	Not utilised	http://www.kgreengrowthpartnership.org/#Current-Events
23	Carbon Finance Assist (CF-Assist)	Multilateral	Mitigation	CF-Assist strengthens the capacity of client countries to understand, integrate, and develop low-carbon initiatives consistent with their NDCs, sustainable development priorities, and country climate action strategies.	Not utilised	https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/climate+business/blendedfinance_ifccanada

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
24	Clean Technology Fund (CTF)	Multilateral	Multiple foci	The Climate Investment Funds (CIFs) were established by developed and developing countries and are implemented with the multilateral development banks (MDBs) to bridge the financing and learning gap between now and the next international climate change agreement. CIFs are two distinct funds: the Clean Technology Fund and the Strategic Climate Fund.	Utilised	https://www.climateinvestment-funds.org/topics/clean-technologies
25	Forest Investment Programme (FIP)	Multilateral	REDD+	The Forest Investment Programme (FIP) is a targeted programme of the Strategic Climate Fund (SCF), which is one of two funds within the framework of the Climate Investment Funds (CIF).	Not utilised	https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/climate-investment-funds-cif/strategic-climate-fund/forest-investment-program-fip/
26	Scaling-up Renewable Energy Programme (SREP)	Multilateral	Mitigation	The Scaling Up Renewable Energy Programme in Low-Income Countries (SREP) is funded by the Strategic Climate Fund (SCF), one of the two Climate Investment Funds (CIF). SREP aims to scale up the deployment of renewable energy solutions and expand renewable markets in the world's poorest countries. It pilots and demonstrates the economic, social, and environmental viability of development pathways that do not exacerbate global warming.	Not utilised	https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/climate-investment-funds-cif/strategic-climate-fund/scaling-up-renewable-energy-program-in-low-income-countries-srep/

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
27	IFC-Canada Climate Change Programme	Multilateral	Adaptation	The IFC-Canada Climate Change Programme (the "Programme"), established in 2011, is a partnership between the Government of Canada ("GoC") and IFC to promote private sector financing for clean energy, forestry and climate adaptation projects through the use of concessional funds to catalyse investments in low-carbon technologies that would not otherwise happen. The objective of the programme is to address market barriers that prevent the faster, more widespread or longer-term sustainable adoption of low-carbon technologies and business models designed to address climate change.	Utilised	https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/climate+business/blendedfinance_ifccanada
28	Methane Facility (PAF)	Multilateral	Mitigation	This initiative was developed by the World Bank Group and has been currently tested for methane emission reductions in landfills, animal waste and wastewater projects. The PAF delivery model offers a price guarantee for future emission reductions determined through a bidding process, and as such leverages private sector financing and ensures the efficient use of public funds for climate financing.	Not utilised	https://www.pilotauctionfacility.org/

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
29	Transformative Carbon Asset Facility (TCAF)	Multilateral	Mitigation	The Transformative Carbon Asset Facility was established to help developing countries implement their plans to cut emissions by working with them to create new classes of carbon assets associated with reduced greenhouse gas emission reductions, including those achieved through policy actions. The facility seeks to measure and pay for emission cuts in large-scale programmes in areas like renewable energy, transport, energy efficiency, solid waste management, and low-carbon cities.	Not utilised	https://tcaf.worldbank.org/
30	Adaptation for Smallholder Agriculture Programme (ASAP)	Multilateral	Adaptation	The Adaptation for Smallholder Agriculture Programme (ASAP) is IFAD's flagship programme for channelling climate and environmental finance to smallholder farmers. The programme is incorporated into IFAD's regular investment processes and benefits from rigorous quality control and supervision systems.	Not utilised	https://www.ifad.org/web/guest/asap
31	Amazon Fund	Multi Donor National	REDD+	The Amazon Fund monitors and evaluates various regional indicators of the Brazilian Amazon, as well as indicators that measure implementation (outputs) and the positive and negative changes arising from the supported projects (impacts).	Not utilised	http://www.amazonfund.gov.br/en/home/

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
32	UN-REDD	Multilateral	Mitigation & REDD+	The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries was launched in 2008 and builds on the convening role and technical expertise of the Food and Agriculture Organisation of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). The UN-REDD Programme supports nationally led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including indigenous peoples and other forest-dependent communities, in national and international REDD+ implementation.	Not utilised	http://www.un-redd.org/
33	Congo Basin Forest Fund (CBFF)	Multi Donor Regional	REDD+	The CBFF was established in 2008 in partnership with the African Development Bank (AfDB) and the Central Africa Forests Commission (COMIFAC), and funded by Norway and the UK, to mobilize resources to finance activities and projects aimed at promoting the equitable and sustainable use, conservation and management of Congo Basin forests and ecosystems for poverty alleviation, sustainable socio-economic development, regional cooperation and environmental conservation.	Not utilised	https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/congo-basin-forest-fund/

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
34	Forest Carbon Partnership Facility Carbon Fund	Multilateral	REDD+	The FCPF is a global partnership of governments, businesses, civil society, and Indigenous Peoples focused on reducing emissions from deforestation and forest degradation, forest carbon stock conservation, the sustainable management of forests, and the enhancement of forest carbon stocks in developing countries (activities commonly referred to as REDD+).The Carbon Fund builds on the progress made in readiness and is designed to pilot performance-based payments for emission reductions from REDD+ programmes in a small number of FCPF countries.	Not utilised	https://www.forestcarbonpartnership.org/
35	MDG Achievement Fund	Multilateral	Adaptation	The Millennium Development Goals Achievement Fund (MDG-F) is an international cooperation mechanism committed to eradicating poverty and inequality and to accelerating progress towards the Millennium Development Goals (MDGs) worldwide Its aim is to improve livelihoods and to influence public policy, which made it responsive to the needs of the poorest populations.	Not utilised	http://www.mdgfund.org/

#	International Funding Instrument	Financing Typology	Financing Focus	Brief Description	Utilised by South Africa?	Website
36	Indonesia Climate Change Trust Fund (ICCTF)	Multi Donor National	Multiple foci	The ICCTF is a key instrument of the GOI in achieving its mitigation and adaptation targets, supporting both RAN/RAD-GRK as well as RAN-API implementation. Through leveraging and channeling of domestic resources and international funds into projects aligned with Indonesia's RAN/RAD-GRK implementation plan, the ICCTF supports Indonesia's 26% / 41% emission reduction target.	Not utilised	https://www.icctf.or.id/
37	Global Climate Change Alliance (GCCA)	Multilateral	Multiple foci	The GCCA is a flagship initiative of the EU helping the world's most vulnerable countries mainly small islands developing states (SIDS) and least developed Countries (LDCs) to increase their resilience to climate change. This EU initiative helps mainly SIDS and LDCs increase their resilience to climate change. The GCCA+ also supports these group of countries in implementing their commitments resulting from the 2015 Paris Agreement on Climate Change (COP21), in line with the 2030 Agenda for Sustainable Development and the new European Consensus on Development.	Not utilised	http://www.gcca.eu/
38	Global Energy Efficiency and Renewable Energy Fund (GEEREF)	Multilateral	Mitigation	GEEREF is an innovative Fund-of-Funds catalysing private sector capital into clean energy projects in developing countries and economies in transition.	Not utilised	http://geeref.com/

Table 4 - 2: Terms and conditions of funding instruments

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
1	Global Environmental Facility (GEF)	<p>(1) GEF grants that are made available within the framework of the financial mechanisms of the conventions referred to in paragraph 6 shall be in conformity with the eligibility criteria decided by the Conference of the Parties of each convention, as provided under the arrangements or agreements referred to in paragraph 27.</p> <p>(2) All other GEF grants shall be made available to eligible recipient countries and, where appropriate, for other activities promoting the purposes of the facility in accordance with this paragraph and any additional eligibility criteria determined by the council. A country shall be an eligible recipient of GEF grants if it is eligible to borrow from the World Bank (IBRD and/or IDA) or if it is an eligible recipient of UNDP technical assistance through its country Indicative Planning Figure (IPF). GEF grants for activities within a focal area addressed by a convention referred to in paragraph 6 but outside the framework of the financial mechanism of the convention, shall only be made available to eligible recipient countries that are party to the convention concerned."</p>
2	The Adaptation Fund	<p>(1) Only institutions accredited by the Adaptation Fund may receive funding for adaptation projects. After accreditation, the entity may submit project proposals aligned with national priorities for consideration by the Adaptation Fund Board.</p> <p>(2) To apply for project and programme funding, countries must submit proposals through an accredited institution</p> <p>(3) There are three categories of accredited institutions: (i) National Implementing Entities (NIEs); (ii) Regional Implementing Entities (RIEs); and (iii) Multilateral Implementing Entities (MIEs)</p>
3	The Group on Earth Observations (GEO)	<p>(1) Membership in GEO is open to all member States of the United Nations and to the European Union. Membership in GEO is contingent upon formal endorsement of the 2016-2025 Strategic Plan.</p> <p>(2) Membership in GEO is contingent upon formal endorsement of the GEOSS 10-Year Implementation Plan.</p> <p>(3) All members belong to a regional caucus.</p>
4	Future Earth	This open network is made available by Higher Logic and Future Earth ("Community Operators") for the public to share information including sustainability research, Future Earth activities, research results, innovations, events, conferences, vacancies, funding opportunities.

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
5	The Belmont Forum	(1) Recognising the need and value of international cooperation and co-ordination, the funding agencies and scientific councils created the Belmont Forum, an international platform that combines, under a shared vision, their resources for advancing global environmental change research.
		(2) Recognising the importance of the United Nations Sustainable Development Goals (SDGs) as a framework for sustainable development at global level, the forum wants to make a considerable contribution to the implementation of the SDGs under existing conditions of global change by supporting relevant interdisciplinary research.
		(3) The forum supports multi-national and transdisciplinary collaborative research, bringing together natural sciences, social sciences and the humanities as well as stakeholders in co-creating the knowledge and solutions for sustainable development that benefit society.
6	Climate Technology Centre and Network	(1) Requests for technical assistance are submitted by CTCN National Designated Entities (NDE)
		(2) NDEs are selected by each country to coordinate requests from local/national governments, NGOs, and/or the private sector for capacity building and technical assistance.
7	Green Climate Fund	(1) Access to GCF resources to undertake climate change projects and programmes is possible for accredited entities that can submit funding proposals to the Fund at any time.
		(2) An Accredited Entity (AE) may submit a concept note for feedback and recommendations from the Fund, in consultation with the National Designated Authority or Focal Point.
		(3) The recommendation will clarify whether the concept is endorsed, not endorsed with a possibility of resubmission, or rejected.
8	Global Green Growth Institute (GGGI)	(1) GGGI works with in-country governments across ministries and departments as a trusted and neutral advisor to explore the value of green growth opportunities in the context of the country's own growth and development goal.
		(2) The GGGI's services are demand driven, respond to in-country needs and take into account varying national circumstances.
9	Climate and Development Knowledge Network (CDKN)	(1) CDKN is able to provide support through its alliance organisations and procure the best services from around the world.
		(2) CDKN strives to deliver the highest quality technical advice, forge uniquely effective partnerships, and drive the latest and best thinking on climate compatible development.
		(3) CDKN works across four strategic themes: (i) Climate compatible development strategies and plans; (ii) Improving developing countries' access to climate finance; (iii) Strengthening resilience through climate-related disaster risk management; (iv) Supporting climate negotiators from the least developed and most vulnerable countries.

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
10	International Institute for Applied Systems Analysis (IIASA)	(1) IIASA is independent and funded by prestigious research funding agencies in Africa, the Americas, Asia, Europe, and Oceania.
		(2) The work of IIASA is made possible through the generous support of a range of organisations and individuals that share the institute's commitment to independent, interdisciplinary research into pressing global problems.
11	Partnership for Market Readiness (PMR)	(1) Countries interested in joining the PMR as Implementing Country Participants submit an expression of interest to the Secretariat.
		(2) Depending on the availability of funding, a country is invited to present an Organizing Framework for the Scoping of PMR Activities.
		(3) The Organising Framework is presented to the PA for consideration and endorsement. Once a country is confirmed by the PA, it is allocated preparation phase funding in the amount of US\$350 000.
12	Carbon Fund	(1) Reduce your carbon footprint by reducing energy use.
		(2) Support the highest-quality carbon offset projects to go carbon neutral.
13	Carbon Assessment Development Fund (CADF)	Its purpose would be to develop programmes that will yield emission reductions for their later purchase on behalf of the buyer participants in the carbon fund.
14	Forest Carbon Partnership Facility Readiness Fund (FCPF)	A country has to be part of the REDD+ (i.e. a developing country located in a sub-tropical or tropical area) and must have signed a participation agreement to participate in the Readiness Fund.
15	Carbon Initiative for Development (Ci-Dev) Readiness Fund	(1) Ci-Dev strives to demonstrate that performance-based payments for the purchase of certified carbon emission reductions (CERs) can lead to a successful and viable business model that promotes increased private sector participation, and share lessons for replication.
		(2) Ci-Dev seeks to influence future carbon market mechanisms so that low-income countries, and especially least developed ones, receive a greater and fairer share of carbon finance, resulting in high development benefits that avoid carbon emissions.
		(3) It also prioritises to support low-income countries in developing standardised baselines and establishing "suppressed demand" accounting standards in key areas such as rural electrification, household energy access and energy efficiency.
		(4) Ci-Dev contributes proposals to further improve and extend the scope of the Clean Development Mechanism (CDM) for use by least-developed countries (LDCs), in particular for Programmes of Activities (POA).

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
16	BioCarbon Fund Initiative for Sustainable Forest Landscapes (BioCF ISFL)	(1) Each ISFL programme focuses on an entire jurisdiction (state, province, or region) within a country, thereby enabling it to engage with multiple sectors affecting land use and have an impact on a relatively large area.
		(2) In order to reduce GHG emissions from land use across an entire jurisdiction while simultaneously creating livelihood opportunities, the ISFL will partner with other public sector initiatives and private sector actors.
		(3) By taking on the immense challenges of convening public and private actors and creating an enabling environment for sustainable development, the ISFL will provide significant results-based financing (RBF) over a 10–15 year period by purchasing Verified Emission Reductions (VERs).
		(4) The ISFL reflects the demand for progression from relatively small-scale pilot projects to a programme aimed at promoting sustainable land use at scale.
		(5) To work at scale effectively, the ISFL builds on the experiences and lessons learned through the Bio-Carbon Fund's initial work piloting land use projects, REDD+ initiatives, and other sustainable forest and land use programmes.
17	Pilot Programme for Climate Resilience (PPCR) I/II	(1) It is designed to demonstrate ways that developing countries can make climate risk and resilience part of their core development planning.
		(2) It helps countries build on their National Adaptation Programmes of Action and helps fund public and private sector investments identified in climate resilient development plans.
18	Ozone Trust Fund (OTF) (i.e. Montreal Protocol)	(1) For a country to be eligible it must have ratified the Montreal Protocol.
		(2) Where applicable, the proceeds of Montreal Protocol grants to non-governmental institutions are not taxable.
19	Least Developed Countries Fund (LDCF)	(1) The fund, managed by the GEF, supports the world's most vulnerable countries in their efforts to adapt to the effects of climate change.
		(2) The LDCF was designed to address the special needs of the least-developed countries (LDCs) under the UNFCCC.
		(3) As part of its mandate, it helps countries prepare and implement National Adaptation Programmes of Action (NAPAs).
		(4) Target sectors include water; agriculture and food security; health; disaster risk management and prevention; infrastructure; and fragile ecosystems.
		(5) The LDCF focuses on reducing the vulnerability of key sectors identified through the NAPA process, financing on-the-ground adaptation activities that provide concrete results in support of vulnerable communities.

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
20	Special Climate Change Fund (SCCF)	(1) The SCCF complements the Least-Developed Countries Fund (LDCF).
		(2) The SCCF is open to all vulnerable developing countries, unlike the LDCF.
		(3) Adaptation is the top priority. But the SCCF also funds, through separate financing windows, technology transfer, mitigation in selected sectors including: energy, transport, industry, agriculture, forestry and waste management; and economic diversification.
21	Global Fund for Disaster Reduction and Recovery (GFDRR)	(1) The Multi-Donor Trust Fund (of the GFDRR) is used to finance projects around the world and may hold funds from any donor.
		(2) Through its in-country work, GFDRR awards grants for specific activities in line with its seven operating principles: (i) Demand-driven approach to ensure maximum impact; (ii) Leveraging development investments and policies; (iii) Focusing on inclusive design and participation; (iv) Empowering women and mainstreaming gender; (v) Jointly addressing disaster and climate risk; (vi) Developing knowledge and sharing best practices; and (vii) Prioritising a results-oriented approach.
		(3) GFDRR's grants are organised around eight areas of engagement, which represent our priorities in the coming years: (i) Promoting open access to risk information; (ii) Promoting resilient infrastructure; (iii) Scaling up the resilience of cities, (iv) Strengthening hydromet. services and early-warning systems; (v) Deepening financial protection; (vi) Building resilience at community level; (vii) Deepening engagements in resilience to climate change; and (viii) Enabling resilient recovery.
		(4) GFDRR uses monitoring, evaluation, and a focus on results to drive improved performance.
		(5) The Secretariat carries out GFDRR's mission, manages its day-to-day operations, and produces GFDRR's core documents, such as Work Plans and Annual Reports.
22	Korea Green Growth Trust Fund (KGGTF)	(1) No set terms and conditions or eligibility criteria to access funds.
		(2) Support countries (all over the globe) in their efforts to design, plan, and implement Green Growth strategies and investments.
		(3) Provides countries with access to the experiences of policy makers and Green Growth technical practitioners.
23	Carbon Finance Assist (CF-Assist)	(1) CF-A's basic objective is to ensure that developing countries and the economies in transition are able to fully participate in the flexible mechanisms defined under the Kyoto Protocol.
		(2) CF-A works with countries to help them build their human and infrastructural capacity.
		(3) CF-A also facilitate sustainable development gains associated with carbon mitigation projects.
		(4) CF-A also serves to assist countries to create and manage carbon assets in the form of mitigation projects.
		(5) CF-A also seek to help countries to reduce costs of participation in the carbon market.

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
24	Clean Technology Fund (CTF)	(1) Country access to funds require Official Development Assistance (ODA)-eligibility (according to OECD/Development Credit Authority (DAC) guidelines) and existence of active multilateral development bank (MDB) country programmes.
		(2) Project eligibility and level of financing is assessed on potential “transformative” effects as well as project viability in the absence of concessional finance.
		(3) CTF programmes are intended to “stimulate lasting changes in the structure or function of a sector, sub-sector or market” by improving internal rates of return on low GHG emissions investments.
25	Forest Investment Programme (FIP)	(1) It provides direct investments to address the drivers of deforestation and forest degradation.
		(2) FIP grants and low-interest loans help governments, communities, and business stakeholders work together to achieve sustainable solutions supporting the people and economies that rely on forests while maintaining the important environment services that forests provide.
		(3) FIP is designed to increase investments to help countries reduce greenhouse gas emissions from deforestation and forest degradation (REDD), and promote improved sustainable management of forests, leading to emission reductions and the protection of carbon reservoirs.
		(4) FIP is also a vehicle to build on experience and create new means for broad-scale sharing of knowledge on REDD.
26	Scaling-up Renewable Energy Programme (SREP)	(1) The SREP was established to scale up the deployment of renewable energy solutions and expand renewables markets in the world’s poorest countries.
		(2) The SREP aims to pilot and demonstrate the economic, social, and environmental viability of low carbon development pathways.
		(3) SREP financing supports technologies such as solar, wind, bio-energy, geothermal, and small hydro technologies.
		(4) It stimulates economic growth by working with governments to build renewable energy markets, engage the private sector and explore productive energy use.
27	IFC-Canada Climate Change Programme	(1) The programme is form part of a contribution to the Copenhagen Accords fast-start financing to support climate change action in developing countries.
		(2) The programme's funds, invested at concessional, or below market, terms are blended alongside IFC’s own funds to enable climate change investments that would not otherwise happen, due to market barriers preventing sponsors or other financiers from making those investments, and aims at demonstrating the viability of similar projects that can later be financed on fully commercial terms.
		(3) A portion of the programme funds is also used to fund advisory services work to build local capacity, fill information gaps in the market, and enable countries to adopt regulatory and business environments that encourage the private sector to invest in renewable energy, energy efficiency, and cleaner technologies.

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
28	Methane Facility (PAF)	(1) The PAF is an innovative, pay-for-performance mechanism which uses auctions to allocate scarce public funds and attract private sector investment to projects that reduce methane emissions, taking advantage of the Clean Development Mechanism (CDM) infrastructure already in place for implementation.
		(2) The key objective of the PAF is to demonstrate a new, cost-effective climate finance mechanism that incentivises private sector investment and action in climate change in developing countries by providing a guaranteed floor price on carbon reduction credits.
		(3) The guaranteed floor price is delivered through the auctioning of put options supported by donor funding.
		(4) The nature of the put option means that the facility’s resources will only be disbursed after the emission reductions have been independently verified, making the PAF a “pay for performance” facility.
		(5) The PAF will disburse its resources only against independently verified emission reductions, using existing carbon auditing standards such as the CDM or voluntary standards such as the Verified Carbon Standard or Climate Action Reserve.
		(6) The PAF will support projects that cut methane emissions at landfill, animal waste, and wastewater sites.
29	Transformative Carbon Asset Facility (TCAF)	(1) TCAF seeks to test various methods to transfer “mitigation outcomes” between parties transparently and to provide stringent accounting and transparency, thereby ensuring the environmental integrity of the assets.
		(2) TCAF support measurable, reportable and verifiable (MRV) of Nationally Determined Contributions (NDCs) by developing baselines and monitoring the performance of the programmes.
		(3) TCAF assist countries to implement market-based carbon pricing and sectoral mitigation measures in the emitting sectors of these countries' economies.
		(4) TCAF will leverage public finance through these programmes to create favourable conditions for private sector investment in low-carbon technologies, provide blueprints for efficient and low-cost mitigation (globally and at scale), and achieve lasting transformational impact.
30	Adaptation for Smallholder Agriculture Programme (ASAP)	(1) The programme is incorporated into IFAD’s regular investment processes and benefits from rigorous quality control and supervision systems.
		(2) The ASAP fund allows IFAD country programmes to design projects from a climate-informed perspective and leverage resources for technical assistance.
		(3) ASAP funds activities that focus on (i) policy engagement; (ii) climate risk assessment; (iii) women's empowerment; (iv) private-sector engagement; (v) climate services; (vii) natural resource management and governance; and (viii) knowledge management.

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
31	Amazon Fund	(1) The AF was created to raise donations for non-reimbursable investments in efforts to prevent, monitor and combat deforestation.
		(2) It also promotes the preservation and sustainable use in the Brazilian Amazon.
32	UN-REDD	The UN-REDD Programme supports nationally led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including indigenous peoples and other forest-dependent communities, in national and international REDD+ implementation.
33	Congo Basin Forest Fund (CBFF)	(1) The areas of intervention for CBFF grant funding will mainly be those that slow the rate of deforestation, reduce poverty amongst forest dwellers, and contribute to a reduction in greenhouse gas emissions while maximising the storage of carbon.
		(2) The CBF targets to fund around 80 million inhabitants of the Congo Basin, and in particular vulnerable groups (women, Indigenous Peoples groups).
		(3) Eligibility is also extended to non-governmental organisations at the country or regional level; civil society organisations; community-based organisations; research and training institutions; regional, sub-regional and sectoral organisations; and private sector institutions.
34	Forest Carbon Partnership Facility Carbon Fund	(1) Countries that have made significant progress in their REDD+ readiness endeavours may be selected to participate in the Carbon Fund, through which the FCPF will pilot incentive payments for REDD+ policies and measures in developing countries.
		(2) The Carbon Fund will remunerate the selected countries in accordance with negotiated contracts for verifiably reducing emissions more than in the reference scenario.
		(3) The Carbon Fund's payments are intended to provide an incentive to the recipient countries and the various stakeholders – including forest-dependent indigenous peoples, other forest dwellers or the private sector – within each of these countries, to achieve long-term sustainability in financing forest conservation and management programmes.

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
35	MDG Achievement Fund	(1) The MDF-AF seeks to accelerate efforts to reach the Millennium Development Goals (including environmental and climate change issues).
		(2) In terms of the environment and climate change issues, the fund seeks to help reduce poverty and vulnerability in eligible countries by supporting interventions that improve environmental management and service delivery at the national and local level, increase access to new financing mechanisms and enhance capacity to adapt to climate change.
		(3) To qualify for the funds programmes must be conceived by a minimum of two UN agencies in collaboration with national Government and non-governmental counterparts and submitted through the resident coordinator system of the United Nations.
		(4) All proposals must be endorsed by a national steering committee consisting of, at a minimum, a representative of Spanish cooperation, the national government and the resident coordinator as the leading authority of the UN at the national level.
36	Indonesia Climate Change Trust Fund (ICCTF)	(5) 59 countries identified by the Spanish Master Plan for International Cooperation (2005-2008), and approved by the government and parliament of Spain are eligible to apply for assistance from the fund.
		(1) The ICCTF is the only national trust fund dedicated to climate finance in Indonesia equipped with a governmental mandate.
		(2) Through leveraging and channelling of domestic resources and international funds into projects aligned with Indonesia's RAN/RAD-GRK implementation plan, the ICCTF supports Indonesia's 26% / 41% emission reduction target.

#	International Funding Instrument	Instrument Terms and Conditions (or how the instrument works)
37	Global Climate Change Alliance (GCCA)	(1) The EU's GCCA+ flagship initiative supports adaptation and mitigation and disaster risk reduction efforts for building resilience to climate change.
		(2) The GCCA targets mainly least developed countries (LDCs) and small island developing states (SIDS) that are recipients of aid in line with the official OECD Development Assistance Committee List of Official Development Assistance Recipients and the United Nations list of SIDS.
		(3) The EU GCCA+ initiative funds multi-year programmes with an average contribution of EUR 5 million per project (as of end 2017).
		(4) To apply for EU GCCA+ funding, programmes must meet a certain number of eligibility criteria:
		(5) Expressions of interest for EU GCCA+ funding must meet certain eligibility criteria, which are taken into account during the EuropeAid screening of proposals submitted by EU delegations, such as, among others: (i) the quality of the request made and endorsements by the relevant country authorities and/or the EU delegation for a GCCA+ funded action; (ii) the status of the dialogue on climate change between the country and the EU (e.g. quality of related actions, joint declarations); (iii) Political factors such as strategic and/or enforced cooperation with certain countries; and (iv) The role the country plays in the UNFCCC negotiations and commitment to its processes, and efforts in the implementation of related commitments.
38	Global Energy Efficiency and Renewable Energy Fund (GEEREF)	(1) GEEREF is a Fund-of-Funds advised by the European Investment Bank Group.
		(2) GEEREF invests in private equity funds which focus on renewable energy and energy efficiency projects in emerging markets.
		(3) GEEREF's funds concentrate on infrastructure projects that generate clean power through proven technologies with low risk.
		(4) GEEREF's funds target attractive financial investments that also deliver a strong positive environmental and developmental impact.

Table 4 - 3: Climate funds approved for Sub-Saharan Africa projects for the period 2003-2017

#	International Funding Instrument	Total Amount of Funding Approved (USD million current)
1	Global Environmental Facility (GEF)	384.3
2	The Adaptation Fund	126.2
3	The Group on Earth Observations (GEO)	Information unavailable
4	Future Earth	Information unavailable
5	The Belmont Forum	Information unavailable
6	Climate Technology Centre and Network	Information unavailable
7	Green Climate Fund	470.0
8	Global Green Growth Institute (GGGI)	Information unavailable
9	Climate and Development Knowledge Network (CDKN)	Information unavailable
10	International Institute for Applied Systems Analysis (IIASA)	Information unavailable
11	Partnership for Market Readiness (PMR)	5.4
12	Carbon Fund	Information unavailable
13	Carbon Assessment Development Fund (CADF)	Information unavailable
14	Forest Carbon Partnership Facility Readiness Fund (FCPF)	91.2
15	Carbon Initiative for Development (Ci-Dev) Readiness Fund	Information unavailable
16	BioCarbon Fund Initiative for Sustainable Forest Landscapes (BioCF ISFL)	26.0
17	Pilot Programme for Climate Resilience (PPCR) I/II	280.6
18	Ozone Trust Fund (OTF) (i.e. Montreal Protocol)	Information unavailable
19	Least Developed Countries Fund (LDCF)	595.1
20	Special Climate Change Fund (SCCF)	33.5
21	Global Fund for Disaster Reduction and Recovery (GFDRR)	Information unavailable
22	Korea Green Growth Trust Fund (KGGTF)	Information unavailable
23	Carbon Finance Assist (CF-Assist)	Information unavailable
24	Clean Technology Fund (CTF)	580.2
25	Forest Investment Programme (FIP)	195.6
26	Scaling-up Renewable Energy Programme (SREP)	236.8

#	International Funding Instrument	Total Amount of Funding Approved (USD million current)
27	IFC-Canada Climate Change Programme	Information unavailable
28	Methane Facility (PAF)	Information unavailable
29	Transformative Carbon Asset Facility (TCAF)	Information unavailable
30	Adaptation for Smallholder Agriculture Programme (ASAP)	170.0
31	Amazon Fund	Information unavailable
32	UN-REDD	29.2
33	Congo Basin Forest Fund (CBFF)	83.1
34	Forest Carbon Partnership Facility Carbon Fund	91.2
35	MDG Achievement Fund	20.0
36	Indonesia Climate Change Trust Fund (ICCTF)	Information unavailable
37	Global Climate Change Alliance (GCCA)	205.8
38	Global Energy Efficiency and Renewable Energy Fund (GEEREF)	Information unavailable

Table 4 - 4: Climate funds approved for projects in South Africa for the 2003 - 2017

International Funding Instrument	Name of Project	Total Amount of Funding Approved (USD million current)
Global Environmental Facility (GEF)	Market transformation through energy efficiency standards.	6.0
	Reducing the Carbon Footprint of Major Sporting Events, FIFA 2010 and the implementation of the national greening programme in liaison with 2010 FIFA LOC.	1.0
	Sustainable Public Transport and Sport: A 2010 opportunity.	11.0
	Enabling South Africa to Prepare Its Third National Communication (3NC) and Biennial Update Report to the UNFCCC	4.0
	Energy Efficient Low-carbon Transport.	1.3
	GEF UNIDO Cleantech Programme for SMEs in South Africa.	2.0
	Greening the COP17 in Durban.	1.0
	Industrial Energy Efficiency Improvement in South Africa through Mainstreaming the Introduction of Energy Management Systems and Energy Systems Optimisation.	5.8
	Promoting Organic Waste-to-Energy and other Low-carbon Technologies in Small and Medium-scale Enterprises (SMMEs): Accelerating Biogas Market Development.	4.2
	South Africa Wind Energy Project (SAWEP) Phase II.	3.6
	Capacity Building Programme to Implement South Africa's Climate National System.	1.1
	Cities-IAP: Building a Resilient and Resource Efficient Johannesburg: Increased Access to Urban Services and Improved Quality of Life.	8.1
	Equity Fund for the Small Projects Independent Power Producer Procurement Programme (non-grant).	15.0
	Leapfrogging South Africa's Markets to High Efficiency LED Lighting and High Efficiency Distribution Transformers.	No information available
The Adaptation Fund	Building Resilience in the Greater uMngeni Catchment.	7.5
	Taking Adaptation to the Ground: A Small Grants Facility for Enabling Local Level Responses to Climate Change.	2.4
	Technical Assistance Grant for ESP.	No information available
The Group on Earth observations (GEO)	No information available on SA projects.	No information available

International Funding Instrument	Name of Project	Total Amount of Funding Approved (USD million current)
Future Earth	No information available on SA projects.	No information available
The Belmont Forum	No information available on SA projects.	No information available
Climate Technology Centre and Network	No information available on SA projects.	No information available
Green Climate Fund	(FP029) SCF Capital Solutions.	12.2
Global Green Growth Institute (GGGI)	No information available on SA projects.	No information available
Climate and Development Knowledge Network (CDKN)	No information available on SA projects.	No information available
International Institute for Applied Systems Analysis (IIASA)	No information available on SA projects.	No information available
Partnership for Market Readiness (PMR)	Market Readiness Proposal MRP.	0.4
	PMR Programme South Africa.	5.0
Carbon Fund	No information available on SA projects	No information available
Carbon Assessment Development Fund (CADF)	No information available on SA projects.	No information available
Forest Carbon Partnership Facility Readiness Fund (FCPF)	No information available on SA projects.	No information available
BioCarbon Fund Initiative for Sustainable Forest Landscapes (BioCF ISFL)	No information available on SA projects.	No information available
Pilot Programme for Climate Resilience (PPCR) I/II	No information available on SA projects.	No information available
Ozone Trust Fund (OTF) (i.e. Montreal Protocol)	No information available on SA projects.	No information available
Special Climate Change Fund (SCCF)	Reducing Disaster Risks from Wildfire Hazards Associated with Climate Change.	3.5

International Funding Instrument	Name of Project	Total Amount of Funding Approved (USD million current)
Global Fund for Disaster Reduction and Recovery (GFDRR)	No information available on SA projects.	No information available
Korea Green Growth Trust Fund (KGGTF)	No information available on SA projects.	No information available
Carbon Finance Assist (CF-Assist)	No information available on SA projects.	No information available
Clean Technology Fund (CTF)	Eskom Renewable Energy Support Programme – CSP.	264.4
	Eskom Renewable Energy Support Programme – Wind.	85.6
	Expansion of the South Africa Sustainable Energy Acceleration Programme.	57.5
	South Africa Energy Efficiency Programme.	2.7
	South Africa Sustainable Energy Acceleration Programme.	85.0
Forest Investment Programme (FIP)	No information available on SA projects.	No information available
Scaling-up Renewable Energy Programme (SREP)	No information available on SA projects.	No information available
IFC-Canada Climate Change Programme	No information available on SA projects.	No information available
Methane Facility (PAF)	No information available on SA projects.	No information available
Transformative Carbon Asset Facility (TCAF)	No information available on SA projects.	No information available
Adaptation for Smallholder Agriculture Programme (ASAP)	No information available on SA projects	No information available
Amazon Fund	No information available on SA projects	No information available
UN-REDD	No information available on SA projects	No information available
Congo Basin Forest Fund (CBFF)	No information available on SA projects.	No information available

International Funding Instrument	Name of Project	Total Amount of Funding Approved (USD million current)
Forest Carbon Partnership Facility Carbon Fund	No information available on SA projects.	No information available
MDG Achievement Fund	No information available on SA projects.	No information available
Indonesia Climate Change Trust Fund (ICCTF)	No information available on SA projects.	No information available
Global Climate Change Alliance (GCCA)	No information available on SA projects.	No information available
Global Energy Efficiency and Renewable Energy Fund (GEEREF)	No information available on SA projects.	No information available

Table 4 - 5: List of countries in Sub-Saharan Africa receiving climate finance

Climate Finance Recipient Country: Sub-Saharan Africa	Total Amount of Climate Funding Approved (US\$ million current)
South Africa	590.3
Tanzania	211.5
Mozambique	177.1

Niger	168.4
Ethiopia	159.3
DRC	133.5
Mali	124.6
Zambia	120.9
Ghana	113.8
Nigeria	107.2
Rwanda	104.3
Madagascar	104.1
Kenya	97.7
Regional-Sub-SA	89.7
Liberia	89.5
Uganda	88.8
Senegal	85.6
Burkina Faso	83.2
Regional-Africa (Benini, Kenya, Namibia, Nigeria & Tanzania)	80.0
Multi-country-Sub-SA	70.1

Table 4 - 6: Details of utilised international financial instruments in South Africa

International Climate Funding Instrument	Funding Typology	Funding Focus	Status of Utilisation by SA Researchers and Government	Name of Research Project(s) Funded by International Climate Finance Instrument in SA
Global Environmental Facility (GEF)	Multilateral	Adaptation	Utilised	(1) Market Transformation through Energy Efficiency Standards and Labelling of Appliances in South Africa.
				(2) Reducing the Carbon Footprint of Major Sporting Events, FIFA 2010 and the implementation of the national greening programme in liaison with 2010 FIFA LOC.
				(3) Sustainable Public Transport and Sport: A 2010 Opportunity.
				(4) Enabling South Africa to Prepare its Third National Communication (3NC) and Biennial Update Report to the UNFCCC.
				(5) Energy Efficient Low-carbon Transport.
				(6) GEF UNIDO Cleantech Programme for SMEs in South Africa.
				(7) Greening the COP17 in Durban.
				(8) Industrial Energy Efficiency Improvement in South Africa through Mainstreaming the Introduction of Energy Management Systems and Energy Systems Optimisation.
				(9) Promoting Organic Waste-to-Energy and other Low-carbon Technologies in Small and Medium-scale Enterprises (SMMs): Accelerating Biogas Market Development.
				(10) South Africa Wind Energy Project (SAWEP) Phase II.
				(11) Cities-IAP: Building a Resilient and Resource Efficient Johannesburg: Increased Access to Urban Services and Improved Quality of Life.
				(12) Equity Fund for the Small Projects Independent Power Producer Procurement Programme (non-grant).
				(13) Leapfrogging South Africa's Markets to High Efficiency LED Lighting and High Efficiency Distribution Transformers.
				(14) Capacity Building Programme to Implement South Africa's Climate National System.

The Adaptation Fund	Multilateral	Adaptation	Utilised	(1) Technical Assistance Grant for ESP.
				(2) Building Resilience in the Greater uMngeni Catchment.
				(3) Taking Adaptation to the Ground: A Small Grants Facility for Enabling Local Level Responses to Climate Change.
The Group on Earth observations (GEO)	Multilateral	Multiple foci	Utilised	(1) African-European Georesources Observation System.
				(2) Earth Observation and ENVironmental modelling for the mitigation of HEALth risks.
				(3) Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation.
				(4) GEO Network for Capacity Building.
				(5) Global Mercury Observation System.
				(6) A framework for enhancing EO capacity for Agriculture and Forest Management in Africa as a contribution to GEOSS.
Future Earth	Multilateral	Multiple foci	Utilised	(1) SDG Labs Africa.
				(2) African Future Earth Committee (AFEC) meetings.
				(3) Could not find any other information on projects funded by Future Earth in South Africa.

The Belmont Forum	Multilateral	Multiple foci	Utilised	(1) Food System Governance, Food Security and Land Use in Southern Africa.
				(2) Hydro-social and environmental impacts of sugarcane production on land use and food security' across Brazil, India and South Africa.
				(3) Short-term Community Building Project.
				(4) Southern Africa's hydroeconomy and water security.
				(5) Multi-scale adaptations to global change and their impacts on vulnerability in coastal areas.
				(6) Global learning for local solutions: Reducing vulnerability of marine dependent coastal communities.
				(7) Food Security Impacts of Industrial Crop Expansion in Sub-Saharan Africa.
				(8) Hydro-social and environmental impacts of sugarcane production on land use and food security.
				(9) African Food, Agriculture, Land and Natural Resource Dynamics.
				(10) Delivering Food Security on Limited Land.
				(11) IHDBS: South African component of: Savannah Biodiversity project.
				(12) SEAVIEW: Scenario, fishery ecological-economic modelling & viability network.
				(13) ScenNet: South African component of: Scenarios Network for Biodiversity.
Climate Technology Centre and Network	Multilateral	Multiple foci	Utilised	(1) The CTCN does not provide funding but provides in-kind technical assistance in the range of \$50 000 - \$250 000 USD per initiative.
Green Climate Fund	Multilateral	Multiple foci	Utilised	(1) SCF Capital Solutions (FP029).

Global Green Growth Institute (GGGI)	Multilateral	Multiple foci	Utilised	(1) An assessment of the economic impacts of electricity price increases on the mining sector (with the possibility that electricity pricing can incentivise mining-related companies to invest in renewable energy and energy efficiency).
				(2) A case study on South Africa's efforts to align the financial system with green economy principles and processes (for use by UNEP and the GGGI).
Climate and Development Knowledge Network (CDKN)	Multilateral	Multiple foci	Utilised	(1) Climate change and upstream development impacts on new hydropower projects in the Zambezi.
				(2) Development of cutting-edge methodologies to link sectoral (e.g. energy, agriculture, land use) and economy-wide models in order to support climate compatible policies.
				(3) The collaboration of a consortium of seven Southern African universities, including Rhodes University and UCT to develop core and elective modules for a Masters curriculum in climate change and sustainable development.
International Institute for Applied Systems Analysis (IIASA)	Multilateral	Multiple foci	Utilised	(1) Toward a sustainable energy system for all in South Africa.
				(2) Projecting demographic change in South Africa.
				(3) Improving food security in South Africa.
				(4) Advancing the methods of system analysis.
Partnership for Market Readiness (PMR)	Multilateral	Mitigation	Utilised	(1) Market Readiness Proposal MRP.
				(2) PMR Programme South Africa.
Ozone Trust Fund (OTF) (i.e. Montreal Protocol)	Multilateral	Mitigation	Utilised	(1) Technical Assistance Project for the Development Carbon Capture and Storage in the Republic of South Africa.
				(2) Land Bank Financial Intermediation Project.
				(3) South Africa Partnership for Market Readiness,
				(4) South Africa - Eskom Renewables Support Project.
				(5) Eskom Investment Support Project.
				(6) Durban Landfill Gas-to-Electricity Project.

Special Climate Change Fund (SCCF)	Multilateral	Adaptation	Utilised	(1) Reducing Disaster Risks from Wildfire Hazards Associated with Climate Change.
Global Fund for Disaster Reduction and Recovery (GFDRR)	Multilateral	Adaptation	Utilised	(1) Just-in-Time: City Resilience Programme South Africa.
Clean Technology Fund (CTF)	Multilateral	Multiple foci	Utilised	(1) Clean Technology Fund Investment Plan for South Africa. (2) Financial support of the first independent power producers in the country, including the 100 MW KaXu CSP plant.
IFC-Canada Climate Change Programme	Multilateral	Adaptation	Utilised	(1) SASFIN EE.

Table 4 - 7: Obstacles to utilisation of those funding instruments not utilised in South Africa

International Climate Funding Instrument	Funding Typology	Funding Focus	Obstacles to Utilisation
Carbon Fund	Multilateral	Mitigation	(1) High energy requirements for producing hydrogen.
			(2) High CO ₂ utilisation costs compared to conventional ways.
			(3) Lack of enabling policies and legal frameworks.
			(4) Lack of alignment between policy and regulations.
			(5) Difficulties in the estimation of Demand and carbon market characteristics.
			(6) Unequal regional distribution of projects.
			(7) Complex governance procedures.
			(8) Capacity issue.
			(9) Complexity in emission reduction programmes.
			(10) Baseline data deficiencies.
Carbon Assessment Development Fund (CADF)	Multilateral	Mitigation	See Carbon Fund obstacles.
Forest Carbon Partnership Facility Readiness Fund (FCPF)	Multilateral	REDD+	(1) Lack of adequate funding- technology required to measure carbon emissions are very high.
			(2) Complexity in emission reduction programmes.
			(3) Controversy in SA forestry sector, which has largely been blamed for fuelling the spread invasive alien plant species.
			(4) SA is a water scarce country.
			(5) Lack of technical capacity.
			(6) Land tenure drawbacks.
Carbon Initiative for Development (Ci-Dev) Readiness Fund	Multilateral	Multiple foci	See Carbon Fund and CADF obstacles.

International Climate Funding Instrument	Funding Typology	Funding Focus	Obstacles to Utilisation
BioCarbon Fund Initiative for Sustainable Forest Landscapes (BioCF ISFL)	Multilateral	REDD+	See FCPF obstacles.
Pilot Programme for Climate Resilience (PPCR) I/II	Multilateral	Adaptation	(1) Lack of baseline data. (2) Delays in legislation promulgation and policy implementation. (3) Lack of standardised activity based landscape level GhG accounting methodology. (4) Technocentric approaches instead of bottom up approaches involving all stakeholders. (5) Local Capacity issues- lack of adequate skills and expertise required. (6) Carbon market risks.
Least Developed Countries Fund (LDCF)	Multilateral	Adaptation	South Africa is not considered as amongst the least developed countries (together with Botswana, Kenya, Namibia, Swaziland and Zimbabwe).
Korea Green Growth Trust Fund (KGGTF)	Multilateral	Multiple foci	No conclusive obstacles were found, it could be possible that South Africa researchers and the State have not explored this option as yet.
Carbon Finance Assist (CF-Assist)	Multilateral	Mitigation	See Carbon Fund, CADF and Ci-Dev obstacles.
Forest Investment Programme (FIP)	Multilateral	REDD+	See FCPF and BioCF ISFL obstacles.
Scaling-up Renewable Energy Programme (SREP)	Multilateral	Mitigation	This could be attributed to the fact that South Africa is not considered as a low-income country.
Methane Facility (PAF)	Multilateral	Mitigation	(1) Lack of adequate funding-technology required to measure carbon emissions are very high. (2) See PPCR and Carbon Fund obstacles.
Transformative Carbon Asset Facility (TCAF)	Multilateral	Mitigation	See Carbon Fund, PPCR and CADF obstacles.

APPENDIX 5: INVESTIGATION INTO ACTIVITIES AND INVESTMENTS BY THE PRIVATE SECTOR OF SOUTH AFRICA

International Climate Funding Instrument	Funding Typology	Funding Focus	Obstacles to Utilisation
Adaptation for Smallholder Agriculture Programme (ASAP)	Multilateral	Adaptation	No conclusive obstacles were found, it could be possible that South Africa researchers and the state have not explored this option as yet.
Amazon Fund	Multi Donor National	REDD+	This fund is available for countries falling within the proximity of the Amazon.
UN-REDD	Multilateral	Mitigation & REDD+	See FCPF and BioCF ISFL obstacles.
Congo Basin Forest Fund (CBFF)	Multi Donor Regional	REDD+	(1) South Africa does not fall under the Congo Basin Forest Fund (CBFF).
			(2) See FCPF and BioCF ISFL obstacles.
Forest Carbon Partnership Facility Carbon Fund	Multilateral	REDD+	See FCPF and BioCF ISFL obstacles.
MDG Achievement Fund	Multilateral	Adaptation	(1) No conclusive obstacles were found, it could be possible that South Africa researchers and the State have not explored this option as yet.
			(2) It could be attributed to the fact that south Africa has not demonstrated enough commitment and efforts toward achieving millennium development goals.
Indonesia Climate Change Trust Fund (ICCTF)	Multi Donor National	Multiple foci	The instrument only supports programmes in Indonesia.
Global Climate Change Alliance (GCCA)	Multilateral	Multiple foci	South Africa is not classified under small Islands and least developed countries.
Global Energy Efficiency and Renewable Energy Fund (GEEREF)	Multilateral	Mitigation	(1) No conclusive obstacles were found, it could be possible that South Africa researchers and the State have not explored this option as yet.
			(2) It could possibly be attributed to SA's heavy reliance on fossil fuel generated energy.
			(3) It can also be attributed to governance issues - ESKOM has been pro-nuclear and anti-renewable energy of late.

1 Introduction

ASSAf is undertaking a study to assess the funds spent on climate change research and technology development in South Africa. The study aims to inform the DST and Cabinet and form the basis for future policy and funding.

In the previous study, the academic and research sector were well covered. However, the private sector R&D was not well covered. This report aims to provide an overview of the climate change-related R&D in the private sector.

The study did not aim to be exhaustive, but only a qualitative study to understand which sectors of the economy are active in climate change-related R&D and where the companies and investment funds are focusing.

The aim of the study was as follows:

- Identify private equity funds investing in climate change-related technologies in South Africa and provide information on the size of investment (where possible) and nature of technology supported.
- Provide an assessment of financial support to climate change-related technologies in the private sector, including both market funding and internal corporate investment, relative to government investment in this field and investment in technologies in general.
- Provide an assessment of the extent and nature of corporate sector investment in climate change-related research and technology through an assessment of the sustainability and annual financial reports (for larger corporations), information provided by trade organisations (for smaller entities).
- Identify opportunities for South Africa to improve private sector investment in climate change-related technologies; and in particular to coordinate the activities of the private sector with those in the public and academic research sectors.
- Identify some case studies of promising or successful investments in climate change-related technologies by the private sector (or by private-public partnerships), highlighting the learning points.
- Identify any climate change technology gaps relevant to the private sector where South Africa should focus attention, based on international best practice.

2 Study methodology

In order to provide a structure for the study, the private sector was divided into different sectors to ensure that all areas of the economy were well covered and that all areas of funding would be investigated.

- 1 Listed businesses and state-owned entities
- 2 Large and medium-sized businesses
- 3 Small businesses
- 4 Investment funds

For each of the sectors a sample of the businesses or organisations was investigated. The approach for each of the segments was slightly different.

2.1 Listed businesses and state-owned entities

Sample: JSE Top 40 Companies and large state-owned entities.

Approach: A scan of the sustainability reports of the companies and Carbon Disclosure Project (CDP) submissions for the last two years. Interviews with selected sustainability officers of companies.

2.2 Large and medium-sized businesses

Sample: Members/contacts of the following organisations:

Agriculture:	AgriSA
Renewable Energy:	South African Photovoltaic Industry Association (SAPVIA)
	South African Wind Energy Association (SAWEA)
Recycling/Waste:	National Recycling Forum
	Institute of Waste Management of Southern Africa (IWMSA)

Approach: Scan of industry bodies' reports. Interviews with representatives of relevant companies that are involved in climate-related R&D where possible.

2.3 Small businesses

Sample: Innovative companies that are working with the following incubators.
South African Renewable Energy Business Incubator (Sarebi)
Climate Innovation Centre South Africa (CICSA)

Approach: Interviews with the representatives of these incubators. Scan of the reports from the incubators.

2.4 Investment funds

Sample: The following funds and contacts/investments:
Development Bank of Southern Africa (DBSA) Green Fund Inspired Evolution
Industrial Development Corporation (IDC)
Southern African Venture Capital and Private Equity Association (SAVCA)

Approach: Scan of reports from these funds and interviews with the selected representatives of these funds.

2.5 Exclusions

For the study the following areas of interest were intentionally left out:

2.5.1 Technical consultants

There are several companies that offer consulting services in the climate change space to private companies, government and NGOs. Some of them perform research on behalf of their clients. Since work is performed on behalf of clients, this should be picked up under the specific client. For example, a study on different climate change scenarios for a mining company will be covered under the mining company. Work that is done on behalf of government is not considered private sector spending. For this reason, companies that offer these services are not included in this study.

2.5.2 Business consultants

Business consultants and accountants are excluded for similar reasons as technical consultants. However, some of the larger companies, such as McKinsey or Ernst Young do perform some internal research. Research focuses mainly on reporting of climate change related-activities and are desktop studies on how companies react to climate change and report on their activities. The companies do not perform primary research and are not developing any new technology, and are therefore excluded.

2.5.3 Government-related R&D

This study only covers the private sector and excludes government funded institutions, such as the Water Research Commission or GreenAgri in the Western Cape, which are deemed to be public institutions and thus excluded.

2.6 Climate change R&D scope

During the study it was found that the climate change activities in companies mainly focus around three areas.

- 1 Increasing operational efficiencies. Companies are implementing measures to reduce water and energy costs in their operations. An example of this would be a paper company undertaking research on the use of waste heat and how this can be captured and reused in operations.
- 2 Mitigating of threats to operations. An example of this is a mining company undertaking research on mining without the use of water, since more water shortages can be expected in the future under climate change.
- 3 Creation of new business opportunities in mitigation, i.e. reducing GHG emissions. An example of this would be an oil & gas company doing research on CCS, since they expect this to be a new market in the future that can be a new source of revenue or a locally-owned company developing renewable energy technologies.

Many of the activities that companies deploy are not primarily driven by climate change, but are implemented to maximise shareholder value. For this study a wide scope of climate change-related R&D is used. All research that has a significant climate change-related impact is included regardless of whether the decision to perform the research is mainly driven by shareholder value maximisation.

Technologies that are related to sustainable sources of energy are also included in this report. Technologies such as energy storage and fuel cells might not have a direct impact on climate change, however, they are enabling the use of renewable energy and reduce the use of fossil fuels.

3 Listed businesses and state-owned entities

The largest amount of research in the private sector was found in large listed companies with a considerable environmental footprint. These companies have the size and budgets to perform activities that will provide benefits over a longer time horizon.

Among the JSE Top 40 companies it is mainly basic materials, consumer goods and oil & gas companies that seem to perform the bulk of the climate change-related research. Financial and telecom sectors with a limited ecological footprint were not involved in any significant climate change-related R&D.

3.1 Increasing efficiencies

Almost all businesses in the JSE Top 40 mention activities to reduce the energy spend in operations. Where operations are mainly office bound, this is focused on greening the office buildings. There is hardly any research being conducted in this field.

Some large companies in the basic materials are working on generating energy from waste and investigating opportunities and developing technologies. Companies that mention these activities include Anglo American, Mondi, AB Inbev and Tiger Brands. Sasol mentions it is continuing to work on making their business more energy efficient.

3.2 Reducing threats to businesses

Work in this field is mainly related to the lack of water and where this is a threat to operations. Anglo American is developing technologies to be able to do non-aqueous processing of ore. Mining companies are large users of water and water shortages might threaten mining operations in the future.

AB Inbev and British American Tobacco are working with researchers and agronomists to reduce the amount of water required for their agricultural supply chain. This work is not only done in South Africa, but around the world. Woolworths is doing something similar with their Farming for the Future project.

Anglo American and Glencore have also been undertaking research on clean coal technologies and reducing emissions. A change in customer perceptions could be a threat to their coal operations. By promoting clean coal technology, their coal operations could be more future-proof.

3.3 New business opportunities

Anglo American, Glencore, BHP Billiton and Sasol have all been doing research on CCS technologies since this is identified as a new business opportunity. The IPCC has indicated that without CCS, it will be difficult to meet the Paris Agreement climate goals. Large businesses see this as a new business opportunity. Value is directly realised by avoiding the payment of a CO₂ tax or the price of an emission credit, or by the sale of unneeded credits. CCS can be considered as a way to hedge the risk of a high price on carbon. However, the companies have reported limited support from government for the development of these technologies.

Anglo American and BHP Billiton are doing research on the energy efficient use of their materials and how their materials can be used to transition to a greener economy. Bushveld Minerals is performing R&D to promote vanadium flow batteries in South Africa, since it is a primary vanadium mining company. Financial companies are investigating/developing new financial products to enable the procurement of green technologies.

Sustainability officers of companies did indicate that more work should be done on technologies that increase employment opportunities in South Africa. Since climate change can also be an opportunity to establish new industries that create employment opportunities for a large number of people, South Africa should focus more on these opportunities.

3.4 Details from selected businesses

3.4.1 Sasol

Sasol has indicated that they have spent between R50 and R70 million in the last two years on climate change-related research. Most of this work is performed in South Africa.

Increasing efficiency

Sixty per cent of the climate change-related R&D spending by Sasol is linked to increasing operational efficiencies. Work is done to see how renewable energy sources can be used in operations and how operations can be run more energy efficiently.

Reducing threat to operations

Thirty per cent of the climate change-related R&D spending by Sasol is linked to reducing threats to operations. Sasol is a large emitter of GHGs. Changing customer perceptions and the proposed carbon tax are a threat to business. Sasol is doing work to reduce GHG emissions and researching the potential to offset GHG emissions in South Africa through renewables and the development of CCS. Sasol is actively growing low-carbon electricity generation through gas-to-power projects.

New business opportunities

The smallest percentage of climate change-related R&D is focused on new business opportunities. Sasol is working together with the DST in the HySA programme to assist with the development of the hydrogen-based technologies.

3.4.2 Anglo American

Anglo American is a large multinational mining house that has large diamond, coal, iron ore and PGM assets.

Reducing threat to operations

Anglo American reports that about US\$ 1.3 million is spent on different studies that focus on adaptation to climate change. Approximately US\$ 10 million has been invested in research on clean coal technology over the last ten years. The earnings before interest, tax, depreciation and amortisation (EBITDA) of the Anglo American coal business is USD 2.9 billion for 2017 across South Africa, Australia and Colombia. Anglo American is also developing technology to be able to continue mining without the use of water.

New business opportunities

Anglo American has invested US\$ 50 000 in South Africa in a project exploring CCS mineralisation in kimberlite and plans to invest another US\$ 2.2 million into this project. In Australia, Anglo American is sponsoring research in the use of algae to sequester carbon.

Anglo American Platinum will invest US\$ 100 million, over the period 2014 – 2019, in companies that use or enable the use of PGM-based technology in their products or processes. In SA, Anglo American has invested R7 million between 2014 – 2016 in two research programmes that are fuel cell-related. The EBITDA of the Anglo American platinum business is US\$ 866 million for 2017.

3.4.3 Eskom

As the largest producer of electricity in Africa, Eskom is also looking at new technologies to future proof their operations.

Threat to operations

At the Eskom R&D centre, Eskom has established a battery energy storage test site. Currently three batteries from different manufactures and different energy storage technologies are installed. Tests are being conducted to test suitability for the South African environment and the Eskom grid.

New business opportunities

Eskom reports that it has approved research projects in the fields of e-mobility, distributed energy sources, storage and off-grid communities, since these will create new opportunities for Eskom.

No information on the budgets for these projects could be obtained from Eskom.

3.4.4 Bushveld Minerals

Bushveld Minerals is an integrated primary vanadium producer. SA is one of the few countries in the world where vanadium is directly mined and not extracted as a by-product from another commodity.

New business opportunities

Bushveld Minerals has established a subsidiary, Bushveld Energy, as an energy storage project developer and component manufacturer. Bushveld Energy will promote vanadium flow batteries since Bushveld Minerals is a primary vanadium producer.

Since 2016 Bushveld Energy has entered into an agreement with Eskom to test vanadium flow batteries at the Eskom R&D centre. This pilot project is partly funded by the IDC. The battery technology is imported to SA. The vanadium electrolyte was manufactured in China using vanadium mined in SA.

Bushveld Energy aims to build an electrolyte manufacturing facility in SA, but since limited local knowledge is available, the facility will not be designed in SA. Although historically research has been conducted in other energy storage technologies in SA, no specific research on vanadium flow batteries has been performed. Bushveld Energy has indicated that further research in electrolyte and membrane technologies in SA could benefit the industry. It has previously contacted the DST to cooperate.

4 Medium-sized businesses

No structured information could be found regarding climate change-related R&D taking place in medium-sized businesses. Companies of this size are mainly involved in implementing technologies that are already proven.

Companies in the energy sector implement mature technologies such as solar PV and wind turbines that are developed outside of SA. This is in line with the funding that is available from the investment funds.

4.1 Waste

The waste sector is organised in the National Recycling Forum and Institute of Waste Management in South Africa. The DST has developed the Waste Research, Development and Innovation Roadmap to coordinate and manage investments with all stakeholders.

This initiative started in 2015 and the 2016/2017 Annual Report, indicates that the investment in waste RDI is around R1.9 million for the private waste sector during that period (Figure 5-1).

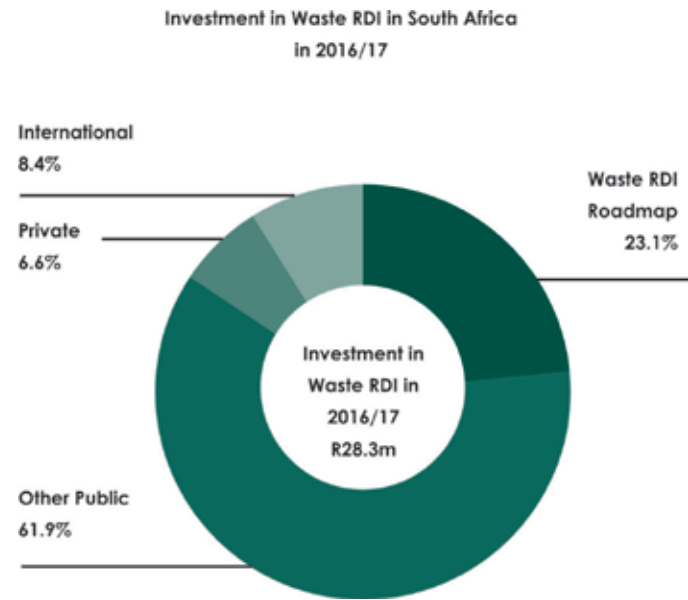


Figure 6 - 1: Investment in waste RDI in SA in 2016/17. Source: 2016/17 Waste RDI Roadmap annual progress report.

In 2017, Mintek finalised a study for the DST regarding the technology landscape in the e-waste sector. It concluded that off-the shelf technologies are readily available from outside South Africa and that only costs and skills are a barrier to implementation.

4.2 Wind

The wind sector is organised in the South African Wind Energy Association. Currently little R&D is ongoing in the wind sector. Technologies from other countries with a much larger wind energy sector are imported into SA. The current size and project-based nature of the industry makes investment in local R&D not feasible.

4.3 PV solar

No information on the R&D for the PV solar sector could be obtained in time for this study.

5 Small businesses

A number of small companies in SA see climate change as a business opportunity. Some of these companies do extensive R&D. However, budgets are small compared to the large listed companies. A number of the companies are linked to business accelerators.

5.1 CICSA

The TIA currently funds the CICSA. The Development Bank of Southern Africa (DBSA) Green Fund previously funded the CICSA by R15 million over the period 2015 to 2017. CICSA is supporting 34 companies that are in an early stage of development. Five companies out of 34 have protected their intellectual property with patents. The companies and the patents are across energy, waste and water.

Only one of the start-ups that is supported comes from the academic sector. This company has developed a new water treatment technology and is the only company that has access to contract research by students. It was noted that there is currently no structure for start-ups to access fast and quick contract research and that research organisations like the CSIR are often outside the budget for small and medium-sized businesses. Universities are trying to develop their own start-ups with the research that is performed in-house.

5.2 Sarebi

The South African Renewable Energy Business Incubator is based in Atlantis in the Western Cape. Very few start-ups linked to the incubator are involved in R&D and no patents have been registered by the start-ups.

Working together with universities is proving to be complicated and expensive. It was mentioned that universities seem to be very protective over their R&D and are trying to commercialise technologies themselves.

Various technologies are supported in the incubator. It was noted that in SA the largest opportunities for start-ups seems to be in the bespoke design of commercial renewable energy or energy efficient technologies.

6 Investment funds

It was found that investment funds do not support any significant research. They are included in this report to provide an overview of the technologies that are supported and that provide opportunities for SA.

6.1 Private equity funds

In recent years, private equity (PE) funds have been set up to invest in resource-efficient businesses and in renewable energy projects. The PE funds all invest in established businesses with established operations that are not performing any research.

In addition, PE funds invest in renewable energy projects that are under-development. Although these are new ventures, the companies only invest in established technologies, mainly in solar PV, wind energy and small hydro.

CSP is not deemed to be viable since the costs of the other technologies have been dropping fast. The benefits of CSP do not outweigh the extra costs. The energy mix that is set out in the Integrated Resource Plan (IRP) and Integrated Energy Plan (IEP) mainly drives investments in these technologies.

At this stage there are no large water-related investments in new technologies. Working with governments or private individuals results in difficult business cases for businesses that focus on water. There might be opportunities for businesses that supply water to private companies in the future.

A list of funds that are investing in climate change-related technology is included at the end of this report in Table 5-1 at the end of this appendix.

6.2 Venture capital funds

No detailed information on the investments of venture capital (VC) funds in climate change-related R&D could be found. However, the SAVCA 2018 Venture Capital Survey does provide an indication of the total amount invested by VC funds at R4.39 billion. Only 5.9% of companies use VC to fund R&D spending.

The investments in climate change-related businesses are not known, but the sector allocation by value of deals indicates small investment in climate change-related businesses (Figure 5-2). Energy (6.7%) and agriculture (1.9%) are traditionally sectors where climate change technology can be deployed, and their allocation is small. Considering the small R&D allocation of VC funds and the small allocation in climate change-related sectors, it can be assumed that VC funds are not involved in any significant climate change-related R&D funding.

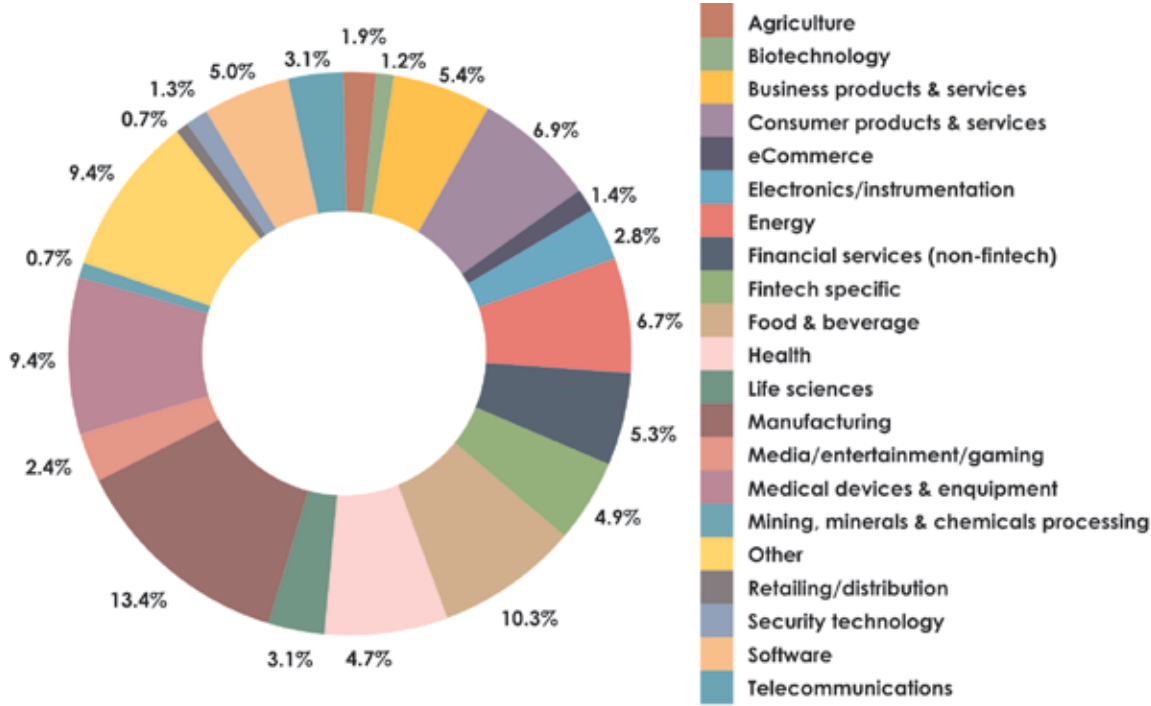


Figure 6 - 2: Sector allocation by value of deals

Source: SAVCA 2018 Venture Capital Survey.

6.3 IDC

The IDC indicates that it does not directly invest in R&D. The IDC does have a New Industries Strategic Business Unit, which invests in eight different industries that have the potential to make a significant impact on South Africa. Of the eight industries, four are climate change-related: energy storage, gas beneficiation, renewable energy inputs and fuel cells.

Since April 2017, the IDC has invested more than R13 million in energy storage in two investments and more than R136 million in renewable energy inputs in two investments. No recent investments in fuel cells could be found, however in 2015, the IDC invested R15.3 million in R&D to develop a practical and workable fuel cell.

A list of the climate change-related investments since April 2017 can be found in Table 5-2 at the end of this appendix.

7 Private sector R&D

The Centre for Science, Technology and Innovation Indicators (CeSTII) conducts an annual survey on R&D in SA. The survey is held among the business sector, higher education, science councils, government and non-profit organisations. Although the data are not climate change R&D specific, the survey does provide an indication of the R&D conducted in the private sector.

The most recent published data is from the 2015/2016 survey. The total response rate for the survey was 73.1%. For the business sector around 2 500 businesses that are likely to perform R&D were selected.

The gross domestic expenditure on research and development (GERD) was R32.337 billion in 2015/16 in South Africa. The business sector funded 38.9% of total expenditure in 2015/16. Investments in green R&D accounted for R8.230 billion or 25.45% of total R&D expenditure. The private sector performs 41.2% of all green R&D activity.

Climate change-related R&D only forms a subset of green R&D and the specific numbers for climate change-related R&D could not be extracted for this study. However, since the private sector accounts for 41.2% of green R&D, it can be assumed that the private sector also performs around 40% of total climate change-related R&D in SA. The total expenditure by the private sector on climate change-related R&D does not exceed R3.37 billion for the period considered in the survey; this is less than 0.1% of GDP.

8 Conclusions and recommendations

8.1 Conclusions

- Large companies perform most of the private sector R&D in climate change. Medium-sized and small businesses generally do not have the budgets and long-term outlook to be involved in climate change-related research.
- Most of the research focuses on new business opportunities that come with climate change. New technologies that need to be developed to combat climate change are a possible new source of revenue. Research focusing on mitigation of threats to operations was mainly focused on water efficiency. Limited research is being performed on increasing efficiencies and using less energy. However, most companies are implementing technologies to be able to operate more efficiently.
- The IDC and private sector seem to be well aligned in terms of new industries that can be beneficial to SA. Energy storage, fuel cells and gas beneficiation are all areas that large listed companies and the IDC are focusing on in SA.
- Almost all mining companies and Sasol have identified CCS as an opportunity. Companies are researching different technologies for CCS. However, limited support from government was reported.
- Investment funds do not support any significant climate change-related research. They mainly invest in mature and established renewable energy technologies. The renewable technologies that are supported and the relative allocation of funds between the different technologies is heavily influenced by the mix set out in the IRP.

8.1 Recommendations

- 1 Future work on the R&D in the private sector should mainly focus on large businesses that are in the basic materials, oil & gas and consumer goods sectors. Large businesses have both the budgets and long-term outlook to be interested in climate change-related R&D. Basic materials, oil & gas and consumer goods have a large environmental footprint that can be changed through R&D and have the resources that enable the transition to a low-carbon economy.
- 2 For a quantitative assessment of the private sector R&D, the CeSTII database should be used. Although the data in the database is not climate change-specific, the database seem to be the most complete database of R&D performed in the private sector.
- 3 Some of SA's minerals can be important for the transition to a low-carbon economy. Especially for energy storage and fuel cells, platinum and vanadium can play an important role. SA holds large vanadium and platinum reserves. Further research on the technologies

that use these minerals will benefit South African mining companies and ultimately the South African economy.

- 4 CCS is an area where a number of large businesses see opportunities. Mining companies are working on leveraging their current assets to play a role in the CCS economy. However, limited academic and government support was reported. More research on these technologies can benefit South African companies and ultimately the South African economy.

Table 5-1: Private equity funds investing in climate change related technology in South Africa

Fund	Focus of Investment
Industrial Development Corporation (IDC)	General investments in companies/projects that benefit South Africa
H1 Holdings	Investments in REIPP projects (Solar,Hydro,Wind) and cogeneration
Public Investment Corporation (PIC)	Investments on behalf of public sector entities
ACTIS	Multi Asset Emerging Market Investor, invested in REIPPP projects in SA
Africa Infrastructure Investment Managers (AIIM) Investments	Investing in Infrastructure in Africa. In SA invested in REIPPP projects
Investec Africa Private Equity	Invested in a number of REIPP projects
Old Mutual Alternative Investments	Invested in a number of REIPP projects
Business Partners Greenfund	Financing and supporting green businesses
Edge Growth	Enterprise Supplier Development funds investing in businesses. Number of investments in energy efficient businesses
EEP Africa	A donor fund providing early stage grant and financing to innovative energy projects, technologies and business models
Metier Sustainable Fund	Investments mainly in renewable energy projects in South Africa
Inspired Evolution	Investments in renewable energy projects and other energy efficient businesses

Table 5 - 2: Climate change-related investments by the IDC since April 2017

Client	Investment Date	Sector	Investment Amount (ZAR)
Du Plessis Solar PV4 (Pty) Ltd	2017/04/06	Industrial infrastructure	1 100 000
ILB Helios Southern Africa (Pty) Ltd	2017/05/15	Machinery & equipment	11 325 0000
Econoheat Energy Efficient Appliances	2017/05/30	Machinery & equipment	14 000 000
Bushveld Energy Company (Pty) Ltd	2018/02/12	New industries	61 5250
Battery Power Industries (Pty) Ltd	2018/02/26	New industries	13 000 000
Mean Sea Level Pty Ltd	2018/03/05	Industrial infrastructure	23 000 000
Econoheat Energy Efficient Appliances	2018/03/18	Machinery & equipment	9 500 000
TOTAL			184 365 250

APPENDIX 6: DETAILS OF THE DATA SOURCES SUPPORTING FUNDING ANALYSES

Various sources have been surveyed to collect information on investment in R&TD activities related to climate change. Sources of information included both funding and recipient/implementing agencies in and outside the country. In several cases, activities have been jointly funded and/or implemented by more than one agency, and hence information on several activities were reported more than once. Data obtained from these sources have therefore been carefully examined and matched to avoid double counting.

Two other challenges remained with processing the information collected for the purposes of this report. The first is the fact that several sources could not separate expenditure on climate change-specific activities from other research and technology development (R&TD) programmes. Also, many significant R&TD investments have been made in programmes that are not aimed directly at managing climate change but contribute to generation of new knowledge and technological innovations that are indirectly related to climate change (energy R&TD is one good example). The collected data also covered a wide range of climate change-related projects, including several non-R&TD activities. Several sources could not provide a breakdown of investment levels by whether an activity/project is specifically R&TD-related or not. It was accordingly necessary to use some criteria to separate investment in climate change R&TD from other activities. Based on information obtained from the said sources on titles of projects or description of the nature of the funded activities, we could develop the following typology to assist with the required separation of climate change-specific R&TD investments:

- 1 Obvious climate change-specific R&TD programmes. Expenditure on activities under these programmes have been **included in full** as R&TD investments. This category includes:
 - a Research activities that are directly related to climate change carried by science councils such as the CSIR, Agricultural Research Council (ARC), HSRC, SAWS, Medical Research Council (MRC), and universities.
 - b Technology development activities specifically directed to management of climate change problems (e.g. adaptation or mitigation solutions) carried by public and/or private agencies specialised in technology development, such as SAEON, Eskom, TIA, SANEDI.

In some cases, a breakdown of expenditure by climate change-specific activities versus others was not provided, and hence information on shares of total budgets used in the first biennial report has been applied (e.g. CSIR, etc.).

- 2 Less obvious climate change-related R&TD activities, which include:
 - a Production of scientific data, analytical tools and other services that are of direct use value for climate change-related R&TD. Examples include provision of data and other services (maps, forecasts, etc.) by the SAWS, the Africa Earth Observatory Network (AEON), the South African Earth Observation Network (SEON), TIA, etc. Expenditure

- on/funding for these activities have been **included in full** with no adjustments in reported amounts, when the required information was available.
- In cases, where the needed breakdown of expenditure was not available, assumptions were needed to determine the share of climate change-specific activities in total investment in the provision of such services. Exclusion of expenditures and revenue from selling of such kind of services by the SAWS to paying clients (i.e. aviation, etc.) from activities funded by public grants and made available for free for use in climate change R&TD activities (as well as planning and policy design purposes) is one example, among others explained in respective sections below.
- a Funding climate change training activities. Since these programmes primarily support postgraduate training and postdoctoral research fellowships, we considered them to represent direct investments in building climate science and research capacities. Accordingly like (a) above, expenditure on/funding for these activities have been **included in full** with no adjustments in reported amounts, when the required information was available.
 - b Activities that are not directly aimed at, but generate indirect benefits to R&TD for managing climate change. Important examples of such R&TD investments include research & capacity building activities of: ACCESS on climate change & earth systems, SANEDI on renewable energy & energy efficiency, TIA on technology development & innovations, NRF-Belmont Forum T2S activities, Eskom and other private sector investments directed to improvements in energy and water supply and use efficiencies, etc. Expenditure on/funding for these activities has been considered to represent a **partial** contribution at an arbitrary share of 50% of reported funds as investment in climate change R&TD.
- 3 Obvious climate change-related but not R&TD activities. Examples of these include:
- a Support to programmes that contribute to design and testing of policy and institutional (i.e. non-technological) innovations (including those involving action-research-type initiatives) to adapt to and/or mitigate impacts of climate change. Examples include some of the DEA and other public and private agencies support to elements of climate response strategies and actions (e.g. research on carbon taxes and some flagship programmes, like the Working for Water, etc.), SANBI's adaptation initiatives, governance, etc. A **partial** contribution of 10% of total expenditure on such activities have been included as investment in climate change-related research and innovation when information on actual shares is not available, which is typical of such programmes.
 - b Funding participation of researchers from SA in international climate change-related R&TD activities and networks.
 - c Activities aimed at promoting uptake and spread of adoption/use of developed and already available climate change-related solutions. Examples include: some DEA climate response strategy flagship (e.g. Energy Efficiency in Public Building Infrastructure Programme, Energy Efficiency and Demand-side Management upscaling & infrastructure expansions), national disaster management, and CSP adaptation programmes, implementation and capacity building activities, support to Integrated National Electrification Plan, etc. Expenditure on/funding for such activities have been considered as purely development projects and **fully excluded** from investments in climate-related R&TD.

Table 6 - 1: Investment in climate change related R&TD (R million) by implementing agency and sources of funding (2015-2017)

Implementing/Host Agency	Source of Funding	2015	2016	2017	Criteria	Source of Information
CSIR (Council for Scientific & Industrial Research)			272.32	255.33		
	WRC		1.55	0.42	Info on climate change shares provided	Pers Com (B Petja, WRC)
	DST Grant	28	29.65	31.11	Applied the ratio of 3.4% of total budget used in FBR	DST Annual Reports 2017 & 2018; and Pers Comm (L Matoowane/DST)
	DST/NRF GCGCP Waste Research SARCHI's		241.12	223.8	50% rule applied	DST Annual Reports 2017 & 2018; and Pers Comm (L Matoowane/DST)
SAWS (SA Weather Services)			20.53	40.87		
	National		19.36	39.29		
	DEA Grant	18.83	19.03	38.85	Excluding revenue from exchange transactions (selling services to aviation & other) & 50% rule	SAWS Annual Reports 2017 & 2020
	Other government		0.34	0.44	Excluding revenue from exchange transactions (selling services to aviation & other) & 50% rule	SAWS Annual Reports 2017 & 2021
	Foreign		1.16	1.58	Excluding revenue from exchange transactions (selling services to aviation & other) & 50% rule	SAWS Annual Reports 2017 & 2022
ARC (Agricultural Research Council)			6.05	2.05		
	NRF-Bilaterals		0.13	0.19	Info on climate change shares provided	Pers Com (M Moeletsi, ARC)
	WRC		0.88	0.24	Info on climate change shares provided	Pers Com (M Moeletsi, ARC)
	DAFF		5.04	1.62	Info on climate change shares provided	Pers Com (M Moeletsi, ARC)
SA MRC (SA Medical Research Council)			2.00	1.70		
	DST Grant		2.00	1.70	Info on climate change shares provided	Per Com (Dr C Wright, MRC)

SANEDI (SA National Energy Development Institute)			115.41	56.69		
	<i>National</i>		95.62	36.90		
	DST Grant		5.25	2.25	50% rule applied	DST Annual Reports 2017 & 2018; and Pers Comm (L Matoowane/DST)
	Other government		90.37	34.65	50% rule applied	SANEDI Annual Reports 2017 & 2018
	<i>Foreign</i>		19.79	19.79	50% rule applied	SANEDI Annual Reports 2017 & 2019
TIA (Technology Innovation Agency)			67.10	69.73		
	<i>National</i>		66.50	69.00		
	DST Grant		66.50	69.00	50% rule applied	DST Annual Reports 2017 & 2018; and Pers Comm (L Matooane/DST)
	DBSA Green Fund		0	0	Information provided	DEA BUR3
	<i>Foreign (UNIDO)</i>		0.60	0.73	50% rule applied	TIA Annual Reports 2017 & 2018
SANBI (SA National Biodiversity Institute)			7.82	11.23		
	<i>National</i>		7.79	10.98		
	DST Grant	2.5	7.79	10.98	50% rule applied	DST Annual Reports 2017 & 2018; and Pers Comm (L Matooane/DST)
	<i>Foreign</i>		0.026	0.25		
	Adaptation Fund		0.026	0.00	10% rule applied on R0.26 million	International Instruments Annex and DEA BUR3
	Green Climate Fund		0.00	0.25	10% rule applied on R 4.95 million over two years	International Instruments Annex and DEA BUR3
Other (universities, consultants)			25.97	16.58		
	<i>National</i>		25.72	16.33		
	WRC	28	1.17	1.64	Info on climate change shares provided	Pers Com (B Petja, WRC)

	NRF-Bilaterals (Norway SANCOOP & Other countries)		12.87	3.74	Info on climate change shares provided	Pers Com (M Moeletsi, ARC)
	DST/NRF Socio-economic Innovation-PROG5		11.68	10.95	50% rule applied	DST Annual Reports 2017 & 2018; and Pers Comm (L Matooane/DST)
	<i>Foreign</i>		0.25	0.25		
	Belmont Forum from SIDA, Sweden)	1.5	0.25	0.25	50% rule applied	Knowledge Fields Developments (2016), Unpublished NRF memo, NRF
Global Change Grand Challenge Programme (GCGCP)		73.95	36.38	38.54	R 110.33 Mil in 2016/17 and more than 100 mil on this programme	Pers Com (L Matooane, DST))
ACCESS (Alliance for Coop on CC & Erath Systems)	<i>DST/NRF Global Change Grand Challenge Programme</i>	16.20	8.42	9.80	50% rule applied	ACCESS Strategy 2017-20 & Business Plan 16-20
SAEON (SA Environmental Observation Network)	<i>DST/NRF Global Change Grand Challenge Programme</i>	14.26	6.91	7.10	50% rule applied on R 27.99 mil in 2016 & R 28.74 Mil in 2017 for SAEON	Pers Com (B Holscher, SAEON & J Diedriks, NRF)
FBIP	<i>DST/NRF Global Change Grand Challenge Programme</i>	10.93	5.30	5.44	2015 share applied to split the total of R 27.99 in 2016 & R28.74 in 2017	No information
GCSSRD	<i>DST/NRF Global Change Grand Challenge Programme</i>	7.00	3.39	3.48	2015 share applied to split the total of R 27.99 in 2016 & R28.74 in 2017	No information
RVSCs	<i>DST/NRF Global Change Grand Challenge Programme</i>	6.00	2.91	2.99	2015 share applied to split the total of R 27.99 in 2016 & R28.74 in 2017	No information

AEON	<i>DST/NRF Global Change Grand Challenge Programme</i>	6.93	3.36	3.45	2015 share applied to split the total of R 27.99 in 2016 & R28.74 in 2017	No information
SOCCO	<i>DST/NRF Global Change Grand Challenge Programme</i>	9.00	4.36	4.48	2015 share applied to split the total of R 27.99 in 2016 & R28.74 in 2017	No information
SARVA	<i>DST/NRF Global Change Grand Challenge Programme</i>	3.63	1.76	1.81	2015 share applied to split the total of R 27.99 in 2016 & R28.74 in 2017	No information
SAASTD (SA Agency for Science and Technology Development)			66.66	69.19		
	<i>DST/NRF Energy Security Grand Challenge Programme (HydroSA, Energy Storage RDI, Renewable Renergy Hub)</i>	112.69			50% rule applied	DST Annual Reports 2017 & 2018; and Pers Comm (L Matoowane/DST)
ESKOM			201.67	213.33		
	<i>National</i>		50	50		
	ESKOM	50	50	50	2015 level maintained	No information
	<i>Foreign</i>		151.67	163.33		
	CTF (Clean Technology Fund)		151.67	163.33	50% rule applied	International Instruments Annex

SASOL	SASOL	60	30	30	Information provided (R 60 mil split for 2 years)	Private Sector Annex
IDC (Industrial Development Corporation)	DTI		7.65	6.5	50% of R 15.3 mil in 2016 & R 13 mil in 2017	Private Sector Annex
Capital Solutions			12.86	13.34		
	<i>National</i>		7.5	7.5		
	DBSA Green Fund		7.5	7.5	Information provided	DEA BUR3
	<i>Foreign</i>		5.36	5.84		
	GCF (Green Climate Fund)		5.36	5.84	50% rule applied	International Instruments Annex
Other Private & public enterprises			188.5	209.19		
	<i>National</i>		57.71	66.5		
	Co-financing (several)		53.29	60.61	50% (energy initiatives) and 10% (development support) rules applied	DEA BUR3
	VC (Venture Capital)		4.42	5.89	5.9% in R&D of which 8.6% in CC (energy & in agriculture) of value of annual investments	Private Sector Annex
	<i>Foreign</i>		130.79	142.69		
	CTF (Clean Technology Fund)		110.55	122.45	50% rule applied	International Instruments Annex
	Bilateral		20.24	20.24	10% & 50% rules applied	DEA BUR3
Anglo American	<i>Anglo American</i>		3.06	3.06	50% of R7 mil in SA over 3 years in fuel cells research & 10% of \$ 1.3 mil in adaptation to CC overall	Private Sector Annex
GRAND TOTAL			1 063.84	1 037.32		



APPENDIX 7: UPDATE OF THE REVIEW OF LEGISLATION AND POLICY INSTRUMENTS FOR CLIMATE CHANGE RESEARCH AND TECHNOLOGY IN SOUTH AFRICA

Introduction

The following report provides an update of the review of legislation and policy instruments included within the first biennial report on the *State of Climate Change Science Research and Technology Development in South Africa* (2017). The report includes a description of the method used to undertake this review and an overview of new policy and legislation which pertains to climate change research and technology development at national and provincial level, and for predominant South African metropolitan municipalities. This review builds on the wider review of South African policy and legislation available in the 2017 report to highlight new developments and significant changes within the South African regulatory environment as it pertains to climate change research and technology development.

Methodology

The updated review of policy and legislative instruments was undertaken through a desktop study. A wide range of documents were gathered within the scope of the 2016 – 2018 time-frame for the review, which allowed for comprehensive coverage of any changes in the regulatory framework which have occurred since the initial assessment was completed in mid-2016. Desktop research relied on 2016 – 2018 green and white papers, bills and acts pertaining to the national level available on www.polity.org.za. A review of relevant provincial and metropolitan municipality websites was also conducted to establish whether advances in climate change R&TD policy and strategy had been undertaken since 2016. The contents of all gathered documents were assessed in terms of their focus on climate change research and technology development, as well as their overall support and facilitation of research and technology development (inclusive of climate change amongst other priority areas in South Africa).

Review

A comprehensive review of the existing legislation and policy which directs and supports climate change research and technology development in South Africa was published in the first Biennial Report (2017) (See Table 7-1 below).

Table 7 - 1: Legislation and policy reviewed in the first biennial report

Policy Type	Policy
White Papers	<ul style="list-style-type: none"> National Climate Change Response White Paper, 2011 Energy Policy White Paper, 1998 Renewable Energy White Paper, 2003
Acts	<ul style="list-style-type: none"> National Environmental Management Act, 1998 and Amendments National Environmental Management: Air Quality Act, 2004 National Environmental Management: Biodiversity Act, 2004 National Water Act, 1998 National Energy Act, 2008 National Skills Development Act, with Amendments
Strategies, Plans and Frameworks	<ul style="list-style-type: none"> National Development Plan New Growth Path Medium-Term Strategic Framework National Framework for Sustainable Development, 2008 National Strategy for Sustainable Development and Action Plan (NSSD1), 2011-2014 National Water Resources Strategy 2 (NWRS 2), 2013 Industrial Policy Action Plan, 2012/2013-2014/15 National Energy Efficiency Strategy (2005, 2008, 2012) Integrated Resource Plan for Electricity (IRP) 2010-2030, Update Report Produced 2013 Carbon Tax Policy Paper, 2013 Draft Climate Change Adaptation and Mitigation Plan for the South African Agricultural and Forestry Sectors, 2015 National Building Regulation and Building Standards Act National Framework for Green Buildings, 2011 Innovative Building Technology Implementation Plan Framework for South Africa's Response to the International Economic Crisis, 2008 National Industrial Policy Framework and the Industrial Policy Action Plans (IPAP) Information and Communication Technology (ICT) R&D and Innovation Strategy, 2007 ICT Research, Development and Innovation Roadmap, 2013 Ten Year Innovation Plan – National Department of Science and Technology, 2008

The following table lists the policies included in this current report, with the intention of updating the above list to incorporate any relevant policy and legislation introduced after 2016.

Table 7 - 2: Recent policies and strategies which direct and support climate change research and technology development in South Africa

Policy Type	Policy
White Papers	<ul style="list-style-type: none"> Aquaculture Development Bill, 2018 Ikamva National E-Skills Institute Bill, 2018 National Climate Change Bill, 2018 National Carbon Tax Bill, second draft 2017 National Research Foundation Amendment Bill, 2017 Protection, Promotion, Development and Management of Indigenous Knowledge Bill, 2016
Acts	N/A

Strategies, Plans and Frameworks	<ul style="list-style-type: none"> Buffalo City Metropolitan Municipality Climate Change Strategy, 2014 City of Johannesburg Air Quality Management Plan, 2017 City of Mbombela Climate Change Response Strategy and Implementation Plan, 2016 Eastern Cape Provincial Development Plan, 2014 Gauteng Innovation and Knowledge Economy Strategy, 2012 KwaZulu-Natal Growth and Development Strategy, 2016 Limpopo Provincial Climate Change Response Strategy 2016-2020, 2016 Limpopo Provincial Development Plan, 2015 Mpumalanga Climate Adaptation Strategy Report, 2016 Msunduzi Municipality Climate Change Adaptation and Mitigation Strategy, 2016 North West Province Department of Rural, Environment and Agricultural Development 2015-2020 Strategic Plan, 2015 Western Cape Climate Response Strategy, 2014
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Broad South African policy frameworks and strategies

Within the broad policy framework of South Africa, no changes have been made to the existing policies and plans. The Constitution remains unchanged as the foundation of national legislation and the current NDP leads the way in determining the development agenda within the country.

National Development Plan

The 2011 NDP focused on Vision 2030 which included an outline of the vision for a "transition to a low carbon economy" in Chapter 5 (NPC, 2011). Since the first biennial review, the implementation of the NDP has continued with the institutional base of implementation being the national Department of Monitoring and Evaluation. The second NPC was appointed by the President in September 2015 to lead and oversee the implementation of Vision 2030 (NPC, 2018). In January 2018, NPC Commissioners Jarrad Wright and Tasneem Essop published a paper on energy in order to update the discussions initiated through the NDP in 2011. Using this paper as a starting point, the Commissioners undertook consultations in relation to the challenges occurring within the energy sector in South Africa and the changes needed in the short and longer term for provide energy in a sustainable form to meet the country's needs. Furthermore, Tasneem Essop is undertaking a dialogue with stakeholders from government, civil society, labour, and business regarding process of achieving a low-carbon economy which incorporates social Justice. The Pathways to a Just Transition in South Africa project is currently midway through its three-year timeframe (2017 – 2019).

Operation Phakisa

One recent national level strategy is Operation Phakisa, launched in 2014. Operation Phakisa is a multi-sectoral programme initiated by the former President to unlock economic potential of key sectors in an accelerated manner. Sectors included in the programme are the maritime or ocean's economy; health care; biodiversity; mining; agriculture, land reform and rural development; and chemicals and waste. Since these are sectors regularly prioritised by climate change researchers, there is the potential for creating linkages between the interventions carried out through Operation Phakisa and climate change R&TD. This potential is further enhanced by the identification of research, technology and innovation as an enabler of Operation Phakisa activities across all its components. However, there are limited details provided in programme documents as to the ways in which research, technology and innovation will be used to support and enable projects. The launch of the SAMREF through Op-

eration Phakisa and the oceanographic and geological research opportunities provided by offshore oil and gas exploration activities are specified as objectives of the oceans economy thrust of the programme. Specific funding provision for research is not addressed. Partnerships between the public and private sectors and the exchange of information and data on a voluntary basis are noted as mechanisms through which applied research and development activities can take place.

Environmental and climate change-specific policy, legislation and strategies

National Climate Change Bill

The National Climate Change Bill was published for public comment in June 2018 by the national Department of Environmental Affairs. The publishing of the Climate Change Bill is a step towards implementation of the national Climate Change Response Policy, as well as meeting the responsibility of the national government to ensure that the Constitutional right to an environment that is not harmful to health or well-being is upheld. The stated central purpose of the Bill is to build an effective national “climate change response and a long term, just transition to a climate resilient and lower carbon economy and society in the context of an environmentally sustainable development framework; while implementing an effective national climate change response, set out in the White Paper on National Climate Change Response and South Africa’s Nationally Determined Contribution communicated to the United Nations Convention on Combating Climate Change secretariat in terms of its Paris Agreement.” The Bill makes provision for national contributions to the stabilising of global greenhouse gas concentrations in the atmosphere. The National Environmental Affairs Minister is tasked by the Bill with setting the national global GHG emissions trajectory. The implications of non-compliance with carbon budget limits are addressed in the Bill through standardised penalties for offenders, while also making provision for extensions to deadlines for full compliance if needed.

The Bill concentrates on mechanisms of policy coordination and the development of a cooperative, integrated response to climate change and its impacts in order to achieve a sustainable, just climate response. The Bill calls for institutional coordination and the establishment of a ministerial committee on climate change at national level. It further places responsibility onto state sector departments, SoEs, provinces, and municipalities to evaluate their climate change response needs; formulate an appropriate response strategy and undertake implementation. The Bill provides for the requirement of the formation of a National Adaptation Strategy which, among other requirements, must include an overall vulnerability assessment of the national vulnerability to climate change; detailing of sectoral, cross-sectoral and geographical level risk. This assessment is intended to facilitate the development of climate change adaptation scenarios.

In its current form, the Bill does not prioritise research and technology development related to climate change and there is no consideration of technology transfer included within the Bill. Budget allocation and funding mechanisms to fund these assessments and the overall implementation of the requirements of the Bill are not incorporated into the Bill.

National Carbon Tax Bill

In 2017, the National Treasury published the National Carbon Tax Bill for public comment after its approval by the National Cabinet. The stated purpose of the Bill is “to provide for the imposition of a tax on the carbon dioxide (CO₂) equivalent of greenhouse gas emissions”. As such,

the Bill allows for a variety of measures to address the challenges posed by climate change. These measures include economic instruments to support reduced emissions, such as establishing appropriate carbon pricing; tax incentives for voluntary actions by taxpayers to reduce greenhouse gas emissions; and the use of carbon emission offsets to reduce carbon-based taxation. The Bill details the mechanisms for the use of these instruments in South Africa as well providing the means for calculation of pricing, taxation and tax-free allowances in relation to carbon and greenhouse gas emissions.

There is no direct mention of climate change research and technology development within the Bill. However, there is increased motivation for the development and adoption of technologies through the Bill’s incentivising of the reduction of carbon production and the adoption of carbon sequestration.

National Research Foundation Amendment Bill

The 2017 Bill to amend the 1998 NRF Act leaves most of the Act intact while revising some terminology and providing the institutional mechanism for determining new national policies and policy guidelines where these are related to the functions of the NRF. The definition of technology is restated as “the manner through which knowledge accumulated through research or observation finds practical application. This definition will contribute to the ways in which the NRF divisions and research facilities will consider and undertake climate change R&TD funding, programmes and projects. In addition, the Bill extends the powers of the Minister to develop, maintain and financially support national research facilities, as well as withdrawing or transferring existing national research facilities. The Bill empowers the Minister to declare a research institution and its eligibility to receive funding. This expanded role of the NRF has potential implications for the procedures and funding for the establishment of new research facilities and institutions for climate change research. The role of the NRF is also expanded slightly in the Bill to facilitate and promote national and international liaison, as well as its established roles in nation and international scientific exchange and collaboration between researchers and research institutions. The inclusion of liaison is pertinent to the building and dissemination of climate change research since this requires participation in multinational platforms and institutions.

Provincial and city policy and strategies

At the scale of the provincial regulatory environments there has been a slight increase in the number of strategies directing responses to climate change. In some provinces climate change response policies have been adopted for the first time and are now available on the websites of provincial environmental departments. Newly available provincial reports are the *Mpumalanga Climate Adaptation Strategy Report* and the North West province’s Department of Rural, Environment and Agricultural Development 2015 – 2020 Strategic Plan. The Mpumalanga report was developed based on climate change vulnerability assessments conducted in the province which enabled the classification of those areas and sectors which are of high priority for specialised adaptation strategies. Overall, the report highlights the sector’s most vulnerable to climate change in the province; presents adaptation opportunities; and recommends adaptation measures for Mpumalanga through institutional arrangements, as well as partnerships; and cites the need to raise funding for implementation. Mbombela, as the capital city of Mpumalanga, has followed the lead of the provincial strategy report and has undertaken to develop a city-level strategy, the Draft City of Mbombela Climate Change Response Strategy and Implementation Plan, as of June 2017.

The Mpumalanga report sees provincially-specific research as a key priority across a range of sectors, including forestry, grassland and savanna ecosystems, biodiversity, water resources, viable alternative means of livelihood for communities, and the socio-economic impacts of climate change impacts, such as those related to health (especially malaria and other vector-based diseases), tourism and climate-related disaster risks. The need for raising funds and building stakeholder partnerships for this research is noted as a priority. The intention of research supporting appropriate responsiveness to national policy on climate smart agriculture and adaptation strategies within the ambit of land use, resource management and agricultural sectors is noted in the strategy. There is very little mention of technology within the report. Where technology and innovation are mentioned, this is in regard to the need for innovation in the mining sector to facilitate operations in the context of harsher climatic conditions and in regard to communities using local technologies as part of a suite of adaptation techniques.

Limpopo Provincial Climate Change Response Strategy 2016 – 2020 (2016) identifies the need for climate change-related research and recognises that provincial-scale data is needed. The strategy advocates for an applied research programme which prioritises climate smart agriculture, crop resilience, community livelihood protection, health, biodiversity and ecosystem threats. Collaboration with universities and stakeholders in the public and private sectors is advocated for. The Limpopo Provincial Department of Economic Development, Environment and Tourism has commissioned a green economy plan which is intended to strongly prioritise technology development and adoption as climate change mitigation and adaptation tools.

The Western Cape Climate Response Strategy, devised in 2014, is now available on the provincial website. In order to accomplish its numerous goals for climate change mitigation and adaptation, the strategy prioritises “ongoing collaborative research in order to monitor changing conditions and provide and improve implementable local climate solutions; develop innovative ways, funding mechanisms and partnerships to effectively and pro-actively respond to changing climatic conditions; and better understand the complexities inherent in these conditions” (2014: 2). There is little mention of technology development within the strategy, except renewable energy and energy efficiency as an initial focus area for intervention – this will require the development, adoption and transfer of appropriate technology and the application of existing research in this sector.

The North West province is taking steps to develop a comprehensive climate change response strategy. A sectoral climate change vulnerability assessment for the province was completed in 2015. This was followed by the North West province’s Department of Rural, Environment and Agricultural Development (READ) 2015 – 2020 Strategic Plan, which highlights the lack of a climate change unit and an allocated budget for implementing climate change response actions and flags a concern for the reliance on external sources for funding climate-related initiatives (North West Department of Rural, Environment and Agricultural Development, 2015). In terms of climate change-related research in the province, partnerships with higher education are prioritised as a key mechanism for knowledge building in these policies.

Policies and strategic plans at the city scale, once accepted and adopted, tend to remain unchanged, with no revision and updating of existing climate change strategies for the largest of the South African cities evident since 2016. Some policies, strategies and management plans which facilitate climate change mitigation and adaptation have recently been developed in large South African cities. These recent strategies incorporate climate change R&TD as a priority in a variety of ways. The Msunduzi Municipality Climate Change Adaptation and Mitigation Strategy (2016) includes amongst its ten goals for mitigation and adaptation a

prioritising of research to support decision-making and the dissemination of current information to all sectors. The use rather than development of green technology is adopted within the Msunduzi Strategy. The Buffalo City Metropolitan Municipality Climate Change Strategy (2014) updates the previously available 2008 draft strategy. In terms of research, the strategy prioritises fisheries research, vulnerability mapping and investigation of vulnerable communities which may have their livelihoods compromised by climate change impacts. Passive thermal housing design and renewable energy technology incubation are also noted as important technology-related aspects of climate change adaptation at the city scale.

As evidenced by the official websites of the metropolitan municipalities, such as Johannesburg, eThekweni and Nelson Mandela Bay, efforts are now concentrated on building resilience to climate change effects and on improving the quality of the local natural systems. Thus, cities with existing strategies for climate change response have seen the formulation of strategies, plans and programmes to support the overarching strategy, for example, the 2017 City of Johannesburg Air Quality Management Plan addresses local air quality concerns in response to the need for climate change mitigation.

Provincial technology and innovation strategies

At the provincial scale, there is some evidence of strategies which aim to facilitate and guide the development of knowledge economies and to support the advancement of innovation. The Gauteng Innovation and Knowledge Economy Strategy (2012), for example, prioritises the acceleration of innovation for the purposes of sustainable development with a concern for open innovation that allows for inclusivity rather than a purely economic productivity focus. The Gauteng strategy includes the development and support of spaces for innovation in its agenda, identifying a climate innovation centre as a priority. Furthermore, provincial growth and development plans in the Eastern Cape (2014), KwaZulu-Natal (2016) and Limpopo (2015) note the importance of technology development processes as an aspect of provincial development with energy security, green economy technology, and technology incubation being prioritised. Prioritisation of these areas of technology development and innovation offer the potential for advancing the technologies needed for mitigation of climate change and adaptation to climate change impacts within provinces.

South African Local Government Association working groups

Responding to the Constitution, the NDP and the requirements of local government, the SALGA has formed a national working group focused on environmental planning and climate resilience. This group deals with environmental regulations and policies; air pollution, environmental; climate change, environmental affairs and sustainability; the Paris Agenda on Climate Change; and environmental management programmes. SALGA also has a national working group focused on municipal innovations and information technology which is concerned with supporting municipalities in dealing with ICT; knowledge sharing, and disruptive technologies & systems. The SALGA Electricity and Energy Provision National Working Group focuses on energy-related matters such as the electricity value chain, renewable energy, integrated resource planning and tariff modelling. These working groups which inform and support local government are relevant to climate change R&TD because they open the door to identifying research which supports municipal-level climate change responses and the uptake of green technology; and can potentially be the mechanisms through which piloting of new technologies and approaches can be facilitated.

Sector-based policies related to climate science research and technology

National Aquaculture Development Bill

The National Aquaculture Development Bill, published for comment in 2018, provides for the responsible growth of the aquaculture sector as a means of economic development, enhanced food security and sustainable livelihoods generation. The Bill is intended to promote the development and management of an aquaculture sector that is characterised by species diversity and the use of a variety of technologies and methods at different scales. A further objective of the Bill is coordinating and undertaking research in the field of aquaculture, as well as the dissemination of aquaculture-related research. This objective is to be partly achieved through the establishment of a national aquaculture research and technology development programme and dedicated research facility. The prioritisation of research and the development of appropriate technology within aquaculture supports climate change R&TD related to a number of priority sectors for climate adaptation, for instance, smart agriculture, food security, biodiversity and green technology.

Policy for climate change-related technological development

Protection, Promotion, Development and Management of Indigenous Knowledge Bill

Published in 2016 by the DST, the Indigenous Knowledge Bill addresses the use of indigenous knowledge for non-profit and commercial purposes. The Bill prescribes licenced authorisation of the use of indigenous knowledge for commercial purposes which facilitates the sharing of any financial benefits of commercialisation with the relevant indigenous community. As such, the Bill offers guidance for local and indigenous climate change technology development which is typically mentioned within the suite of adaptation measures and practices promoted at the local scale.

iKamva National E-Skills Institute Bill

The national Department of Communications' 2018 iKamva National E-Skills Institute (iNeSI) Bill sets out the establishment of an institute for information and communication technologies knowledge production, specifically focused on digital skills and multimedia. iNeSI is intended to operate as a change agent to facilitate systemic change across all sectors for inclusion, advancement and increased competitiveness in the digital economy. The Bill makes provision for iNeSI to work with post-school education and training organisations to build digital skills and to foster "an innovative research network focusing on digital skills and multimedia with links to public and private university networks locally and internationally". The collaborative development of digital and multimedia skills, technology and research networks in the Bill provides a new platform for climate change R&TD and offers a new route for building research partnerships which benefit climate change scientists, the dissemination of knowledge and technology transfer.

Discussion

Overall, the period of 2015 – 2018 has seen the advancement of a legislative and policy framework through which the national climate change response will be directed for the foreseeable future. Draft critical national legislation on climate change and carbon taxation are being reviewed through the public consultation process and at the scale of provinces and

cities there is a strengthening of the climate change and technology development regulatory environment. There is greater evidence of policy and plans for the advancement of technology and innovation at the national and provincial scales, however, these are limited in comparison to the proliferation of climate change-focused policy.

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